THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. X.—OCTOBER, 1893.

ORIGINAL ARTICLES.

I.—Some Cretaceous Pycnodont Fishes.

1.—On *Athrodon*.

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE XVI.)

IT is well known that the crushing teeth of the Pycnodont fishes as a rule are arranged with striking regularity upon the bones which bear them, the vomer in the upper jaw and the splenials in the lower jaw. They are disposed in longitudinal series, gradually increasing in size backwards, and there is only one genus satisfactorily known (*Mesodon*) in which there is any marked tendency towards the frequent disturbance of this linear arrangement.

Thirteen years ago, however, Dr. Sauvage referred to the Pycnodonts some very robust splenial bones on which the teeth exhibited scarcely any regularity either in size or arrangement, and more specimens have subsequently been discovered which seem to justify his determination. For the fish to which these bones belonged, Dr. Sauvage proposed the generic name of *Athrodon*; and two species were described from the Portlandian and Kimmeridgian formations of the north of France.

That *Athrodon* does pertain to the family of Pycnodontidæ and is generically distinct from any of the satisfactorily determined forms may now be regarded as certain. So far as the present writer has been able to observe, the Pycnodonts never exhibit successional teeth; when the fish is young the teeth on the splenial and vomer vary little in size and are comparatively irregular; when the fish grows the bone extends and widens backwards, the series of teeth rapidly assuming their regular and distinctive characters. The splenial bone of *Athrodon* also exhibits no successional teeth, and it is thus apparently to be regarded as a genus of Pycnodonts, in which the initial irregularity of dental arrangement persists more or less throughout life. There is a tendency towards the differentiation of a principal longitudinal series of teeth in some species; and in a general way the number of series that would be present, if there were less irregularity, can be counted. The splenial bone, however, does not differ from that of other Pycnodonts merely in its dentition; it is more robust than in other genera, and the roughened symphysial facette is at least twice as deep as usual. In some specimens, indeed, the dentition is perhaps insufficient to determine whether they per-

tain to *Mesodon* or *Athrodon*, and in these cases the form of the symphysis must be relied upon. The teeth themselves are mostly smooth and rounded, sometimes in part mammillated.

If, as seems probable, the characters of the splenial dentition suffice to determine the species of *Athrodon*, seven forms are now known to the present writer. Besides the two French species Dr. Sauvage has already recognised the occurrence of a third in the Kimmeridgian of Hanover (*A. Wittei*); another has been described by Cornuel from the French Neocomian under the name of *Pycnodus profusidens*; one new species occurs in the Purbeckian, and another in the Cenomanian of England; and there is evidence of a third new species in the Senonian of Belgium. These may be enumerated as follows :—

1. Athrodon Douvillei, Sauvage.

Bull. Soc. Géol. France [3] vol. viii. 1880, p. 530, pl. xix. fig. 5.
Type. Left splenial bone; School of Mines, Paris.

The type species. Splenial bone longer than broad, with very small, widely spaced teeth, mostly circular and conspicuously mammillated, disposed in from 7 to 10 irregular series, somewhat enlarged towards the symphysial margin of the bone.

The dentition of the type specimen measures 0·019 in maximum width and 0·045 in length.

Form. and Loc.—Lower Portlandian; Boulogne.

2. Athrodon boloniensis, Sauvage.

Bull. Soc. Géol. France [3] vol. viii. 1880, p. 531, pl. xix. fig. 6.
Type. Right splenial bone; School of Mines, Paris.

Splenial bone comparatively elongated, with large, widely spaced teeth and few intercalated small teeth, mostly circular and conspicuously mammillated, disposed in about 4 to 6 series, scarcely enlarged towards the symphysial margin of the bone.

The dentition of the type specimen measures 0·027 in maximum width and 0·057 in length.

Form. and Loc.—Lower Kimmeridgian; Brecque-recque, Boulogne.

3. Athrodon Wittei, Fricke, sp.

H. E. Sauvage, Bull. Soc. Géol. France [3] vol. viii. 1880, p. 531.
Mesodon Wittei, K. Fricke, Palæontogr. vol. xxii. 1875, p. 364, pl. xix. fig. 15.
Type. Imperfect right splenial bone.

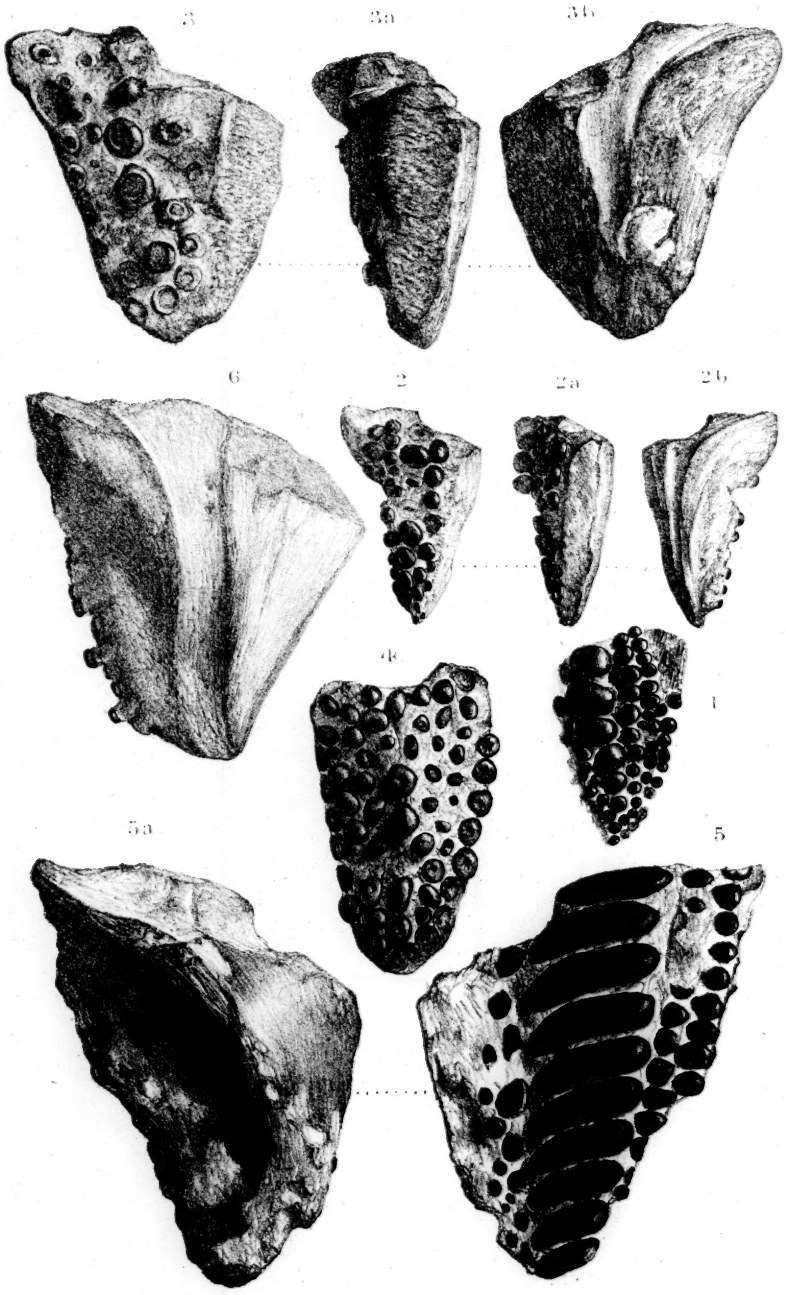
Splenial bone with small, widely spaced teeth, mostly circular and feebly mammillated, disposed in about 7 or 8 irregular series, of which that next to the innermost forms a relatively large principal series.

Form. and Loc.—Lower Kimmeridgian; Hanover,

4. Athrodon intermedius, sp. nov. Pl. XVI. Fig. 1.

Type. Left splenial dentition; British Museum (No. 40314).

Splenial bone comparatively elongated, with large, closely-arranged teeth, mostly smooth and nearly circular, a few exhibiting an apical pit with feebly crimped margin, disposed in about 5 or 6 irregular



F. H. Michael del. et lith.

Mintern Bros. imp.

CRETACEOUS PYCNODONTS.

series, the largest forming a principal series near the symphysial margin of the bone.

The dentition of the type specimen measures 0·017 in maximum width, and 0·03 in length.

Form. and Loc.—Purbeckian; Aylesbury, Buckinghamshire.

5. Athrodon profusidens, Cornuel, sp.

Pycnodus profusidens, J. Cornuel, Bull. Soc. Géol. France [3] vol. v. 1887, p. 609, pl. xi figs. 3–6.

Type. Splenial dentition.

Splenial bone short and broad with closely arranged teeth of moderate size, mostly smooth and circular, a few with a faint apical pit, disposed in about 7 irregular series, the largest near the symphysial margin of the bone.

Each splenial dentition in the type specimen measures 0·026 in maximum width and 0·059 in length.

Form and Loc.—Neocomian; Wassy, Haute Marne.

6. Athrodon crassus, sp. nov. Pl. XVI. Fig. 2.

Type. Right splenial bone with abraded dentition; Woodwardian Museum, Cambridge.

Splenial bone short and broad, with large, widely spaced teeth, mostly circular, disposed in about 4 irregular series, largest near the middle of the bone.

The dentition of the type specimen measures 0·02 in maximum width and 0·04 in length.

Form. and Loc.—Cambridge Greensand; Cambridge.

7. Athrodon tenuis, sp. nov. Pl. XVI. Fig. 3.

Type. Right splenial bone; Royal Museum of Natural History, Brussels.

Splenial bone elongated, with large closely arranged teeth, mostly smooth and nearly circular, disposed in about four irregular series, of which that next to the innermost is the largest.

The dentition of the type specimen measures 0·012 in maximum width and 0·027 in length.

Form and Loc.—Lower Senonian; Lonzée, near Gembloux, Belgium.

8. Athrodon, sp. Pl. XVI. Fig. 4.

In addition to the foregoing it may be mentioned that the Woodwardian Museum, Cambridge, possesses an imperfect vomerine dentition from the Cambridge Greensand, which probably pertains to *Athrodon*, but appears to be too small for *A. crassus*. Nearly all the teeth seem to have exhibited an apical pit with crimped border, and their contour is mainly circular. The largest teeth occur in a discontinuous median row, and there is evidence of three irregular series on each side, not forming quite symmetrical pairs.

Probably many other examples of the dentition of this interesting Pycnodont genus exist in collections, and it is hoped that these brief notes may lead to their recognition. The writer would only add on

the present occasion an expression of his indebtedness to Professor McKenny Hughes and MM. Dupont and Dollo for the opportunity of studying the specimens in the Museums of Cambridge and Brussels.

(*To be continued in our next Number.*)

II.—Contributions to the Geology of Africa.

By Miss Catherine A. Raisin, B.Sc.

I.—Rock Specimens from Upper Egypt.

THE following notes have been drawn up from a study of specimens which were collected by G. F. Scott Elliot, Esq., during the earlier of two recent expeditions in Africa. He followed the Nile to somewhat beyond the second cataract, and brought back more than 130 examples of various rocks. The collection was sent to University College for examination, which I was allowed to undertake by the kindness of Professor Bonney, to whom I am further indebted for much help and advice on points of difficulty. A detailed description has been furnished to Mr. Scott Elliot to be included in the account of his journey, which it is to be hoped will be published before long. It may, however, be useful to have a short summary of the chief points of geological interest for general reference in an easily accessible publication.

A few illustrations of the well-known sandstones and limestones were brought from near Cairo, but with the exception of these (four in number) all the specimens were obtained from Upper Egypt, between latitude just north of 24° N. near the first cataract, and about latitude 21° 30′ N., south of Sarras, beyond the second cataract.

As many writers have now described, the sedimentary strata rest over a wide area in Egypt, Sinai and Palestine upon an old crystalline series.[1] While certain at least of these latter rocks are evidently igneous, others are described as presenting difficulties in field examination, and similarly, gradations from granite to gneiss can be traced in microscope slides. Thus, although a crystalline series of Archæan aspect doubtless occurs, traversed by ancient dykes and intrusions,[2] it is not easy, and in many cases not possible, to separate the hand specimens (even when illustrated by microscopic sections) into the two classes.

Normal granites are shewn in the well-known coarsely porphyritic variety from the Assouan quarry, and in several which have a binary character. In the more or less gneissoid rocks (of which some at least are probably Archæan) the foliation exhibits differences. In certain sections zones of mosaic undulate around

[1] See description of specimens by Prof. T. G. Bonney, in Geol. Mag. 1886, Dec. III. Vol. III. pp. 103–106; Prof. Dawson, Geol. Mag. 1888, pp. 439, 440, 481, 482; K. A. von Zittel, "Ueber den geolog. Bau der libyschen Wuste," 1880, p. 9.

[2] See references above; and also 'Géol. de Palestine," M. L. Lartet, p. 55. I have to thank Mr. L. L. Belinfante, B.Sc., the Curator of the Geological Society, for kindly giving me facility to examine the collection brought by Mr. J. C. Hawkshaw, which was interesting for comparison, and included some similar types.

lenticular, rather broken-looking, fragments with shaded border, the edge of the larger grains is cracked, and thin wavy laminæ of mica and hornblende sometimes traverse the slide. These characters have been often described and are doubtless due to subsequent pressure. Other examples shew a clear undisturbed intercrystallisation of the constituents, which are chiefly a quartz-felspar mosaic, large felspars (microcline or kaolinised plagioclase) and well formed biotite not streaked out in layers. The appearance of banding, and some elongation of the grains, may perhaps be attributed to a movement of the original magma, and the structure thus may be related to that which has been described from the districts of the Lizard and of Sark.[1]

The diorites obtained from near Assouan have rather the character of intrusive masses, and may be connected with the dykes which have been described as cutting the basal series. From the second cataract, in addition to the felspar-hornblende rocks, which appear to be dykes, some well-marked clear diorites occur, possibly belonging to an old crystalline series, and the description suggests that they are parts of large masses, forming the typical rocks of the district. The hornblende in all appears secondary, affording illustrations of various modes of its development from augite. A crushed diabase was brought from south of Sarras and also a chlorite-schist.[2]

The specimens from undoubted dykes include basalt and micro-granite (Assouan), porphyrite (Kalabsheh) and other varieties. One point of interest is the fairly large number of rocks from near Assouan which are connected with the mica-trap group [35, 36, 26]. They vary from somewhat micaceous diorites to well-developed kersantites; they have often an orientation in the mica, and lead up to specimens which are really mica-schists in appearance. It is interesting to have further illustrations of this group of not very common igneous rocks, which had already been shown by Professor Bonney to exist in the district, in his description of specimens brought by Sir W. Dawson.[3]

A schistose character is also found in certain hornblende rocks which are described as dykes [32, 34]. They are certainly igneous, and consist of plagioclase felspar and green dichroic hornblende.[4] The absence of pressure effects and the appearance of quiet crystallization suggests that the foliation again here may be a fluxional structure. A dyke from Elephantine [33] is a rather exceptional rock, of a dull red colour, the slide consisting of plagioclase felspar, of a brown, probably ferriferous hornblende, allied to arfvedsonite,

[1] Q.J.G.S. 1891, vol. xlvii. p. 497, Prof. Bonney and Major-Gen. McMahon on the Crystalline Rocks of the Lizard District. Q.J.G.S. 1892, vol. xlviii. pp. 132–138, Rev. E. Hill and Prof. Bonney, on the Hornblende Schists of Sark.

[2] This specimen may possibly be related to a chlorite-schist which has been described from the borders of Abyssinia.

[3] Geol. Mag. 1886, p. 106.

[4] The hornblende is in clear rounded grains in one slide, which also contains a light-coloured augite similar to a variety shown to me in a Hebridean diorite by Prof. Bonney. Another of the hornblende-felspar rocks, as Prof. Bonney also pointed out, bears some resemblance to a foliated diorite in Guernsey.

of pale violet-coloured augite and dense interfelted granular masses, including an acicular mineral (? a zeolite) and analcime. If these patches replace original crystals, their outlines are not now distinguishable, but the aggregates very possibly resulted rather from alteration of a ground-mass filling up interspaces. The rock bears some resemblance to the augite syenite described by Brögger from Norway; although the presence of nepheline or elæolite cannot be proved,[1] and, as stated just previously, the mass very probably was not even holocrystalline, but possessed an andesitic matrix. The augite has definite outlines, and probably was formed early, and hornblende was developed partly by conversion of the augite, partly as a zone surrounding it.

Certain syenitic or granitic rocks from near the second cataract appear from the description to be intrusive in the diorite, and the evidence from some junction specimens, although not decisive in single examples, is in favour of this view. [113.] In one, the granite is coarsely crystalline, but the diorite forms a small piece, which probably has been included in the heart of the intruding mass. In the fragment, greenish hornblende is in the form of aggregates of small crystals confusedly orientated, enclosing in a few cases a partially decomposed core of augite. But in addition to characters which are common in a hornblende-diabase or uralite, a further alteration can be traced. Small crystals of clear brown mica form a zone along the border of the original pyroxene. These range roughly parallel to the boundary, or they project outwards penetrating the adjacent felspar; sometimes a small group occurs surrounded by felspar (Fig. 1). Thus, as Prof. Bonney has suggested in connection with a specimen from Sark, the mica seems to have crystallized at the expense of the felspar and the pyroxene.[2] This secondary development possibly may be due to the influence of the intruding granite, for it is the kind of change which we generally associate with contact metamorphism, and we note here that the mica films are smaller than the size of the felspar and pyroxene would lead us to expect (see Fig. 1. p. 442).

[87.] The diorite in another contact specimen also shows peculiar alterations. Dull green or brown dichroic crystals, partly of hornblende, partly of brown mica, are scattered with a rough orientation within a mass of plagioclase felspar. The felspar is generally idiomorphic and has a sharp demarcation between a kaolinised interior and a clear external zone (Fig. 2). The intrusive rock is a reddish felstone; it consists mainly of a micrographic mass surrounding and often growing from rectangular cores of dusty felspar, which themselves are sometimes zoned. If we may infer, as has been pointed out by Professor Bonney in the "syenite" of Charnwood,[3] that for the formation of this micrographic structure the rock

[1] The interfelted mass bears some resemblance to that in a nepheline syenite from Montreal, shown to me by Prof. Bonney.

[2] Q. J. G. S. 1892, vol. xlviii. p. 131, fig. 3.

[3] Q. J. G. S. 1891, vol. xlvii. p. 105. On a Contact-structure in the Syenite of Bradgate Park, by Prof. T. G. Bonney.

mass was kept for a long time at a low temperature, the peculiar character of the diorite may have resulted from the "stewing" undergone, and so may possibly be a kind of contact metamorphism.

One specimen of an andesite—a pale peach-coloured rock—contains fairly large fragments, among which clear glassy quartz is conspicuous. The microscope shows that these included parts are a foreign element (quartz and felspar) evidently belonging to a rather coarse granite or granitoid rock. They vary in size, from $\frac{1}{4}$ inch to small microscopic pieces. The edges, sometimes straight along cleavage boundaries of the felspar, seem sharp, and show no evidence of melting down, unless a narrow border with lighter streaks indicates such an effect. The ground-mass is evidently glassy, exhibiting fluidal structure, and it seems to represent an andesitic magma, which has broken through and enclosed fragments of a granite or gneiss.

Specimens of rocks collected from near the base of the overlying sandstones at Abu Seir and at Kormoon are very rotten, but appear to be much decomposed basalts or dolerites, now consisting mainly of a ferruginous mass with a pinite-like mineral. They might represent old lavas which flowed above the massive igneous series; but they more probably are dykes intrusive in the underlying rocks or more or less along the junction plane.

Among the lower crystalline rocks the signs of deformation are not very marked, although on some specimens the great earth-movements or local disturbances have left their impress. Thus a much crushed and consolidated diabase occurs at more than one place;[1] some gneisses of Assouan show structures due probably to pressure of ancient date, and some other illustrations can be found; but on the whole the disturbance is certainly not extreme.

The overlying sedimentary rocks appear to be almost horizontal and undisturbed. They are in nearly all cases sandstones of the Nubian type and consist mainly of quartz and felspar (often microcline) frequently forming a true arkose. Thus they were evidently derived from the disintegration of the lower crystalline rocks.

Sands cemented by iron oxide form a kind of 'pan' such as has been noticed in previous explorations.[2] This character often appears to be associated with a hot, dry climate and a short but heavy rainfall on a sandy country. The accretion of secondary quartz pyramids is also illustrated,[3] and the grains are rounded and angular, including probably a mixture of materials transported by wind and by water. The drifting of desert sand would doubtless smooth rock-surfaces, and some beautifully polished specimens have been brought from the Nile Valley. The glaze[4] may indeed have been added to by

[1] One specimen is from far south beyond Sarras; others from further north near Wady Halfa.

[2] Mineralog. and Petrogr. Mittheil. G. Tschermak. 1886, vol. viii. p. 24; Across East African Glaciers, Dr. H. Meyer, p. 347.

[3] See J. A Phillips, Q.J.G.S. 1881, vol. xxxvii. pl. ii. figs. 1, 2, 3, 5.

[4] See M. L. Lartet, Géol. de Palestine, p. 57; similar specimens are described by J. C. Hawkshaw, Q.J.G.S., vol. xxiii. p. 116.

deposition from water, but below the level of High Nile, whence most of the specimens were obtained, we note in photographs taken by Mr. Scott Elliot that sand is piled up abundantly around the hard rocks. Also the streaked and furrowed surface resembles sand-polished rocks from elsewhere.

From these specimens we can make only a few general inferences —and those not entirely new—as to the order of succession. It seems probable that granite and gneiss near the first cataract, and diorite near the second, form a fundamental crystalline series. At some later epoch or epochs, igneous irruptions occurred of acid, intermediate, and basic rocks. Among these are the numerous mica-traps, or mica-diorites from near Assouan. Near Wady Halfa felstone and granite seem to cut the diorite, while an andesite is perhaps still later cutting the granite. Basic magmas subsequently were intruded as dykes, or possibly were poured out as lavas. The disturbed period marked by igneous action was followed by denudation of the lower crystalline rocks and the tranquil deposition of the overlying sandstones and arkose.

The specimens which have been examined may be arranged roughly in the following classes, the order of succession in certain cases being somewhat hypothetical:—

1. Crystalline rocks, probably fundamental; granite, gneiss, diorite.
2. Igneous rocks, probably intrusive.
   (*a*) Near the first cataract: microgranite, basalt, porphyrite, augite-syenite (?), mica-trap, diabase.
   (*b*) Near the second cataract:
      (1) Intrusive in diorite, granite or syenite: microgranite, felstone.
      (2) Intrusive in granite: andesite.
      (3) Basalt or dolerite (lava flow or intrusive).
3. Sandstones and arkose.

II.—Specimens from West Africa (Sierra Leone).

In a second African expedition, starting from the west coast, Mr. Scott Elliot collected about a hundred rock specimens, which also have been examined at University College under the supervision of Professor Bonney. A detailed account has been furnished to Mr. Scott Elliot, and is published in the Colonial Report on Sierra Leone,[1] but a short summary of the results may be of interest.

The foliated rocks, of which many are certainly igneous, doubtless belong to an ancient series. They include gneiss, and foliated granite, sometimes containing hornblende or biotite. But few specimens appear to have been severely crushed. The igneous rocks, other than granite, are doubtless, in some cases, dykes or sills and intrusive masses, but many examples equally well might be parts of lava flows, a question to be decided only by field examination. Petrologically they are mainly dolerites, often interesting from the presence of olivine, enstatite or hypersthene. A tendency to a spherulitic structure is shewn in one specimen,

[1] Colonial Reports. Miscellaneous, No. 3, Sierra Leone. Reports on Botany and Geology, 1893. I regret that, as I unfortunately missed seeing the proof of this paper, some printers' errors in it have escaped correction.

which is a compact rock, probably from near the edge of an enstatite-dolerite mass.

The sedimentary rocks seem to belong to at least two periods. Some strong grits and conglomerate, lithologically resembling the Welsh Cambrian or Scotch Torridonian, are probably of old Palæozoic, or even earlier age. Differing from these are quartz-sandstones, sometimes ferruginous, which are very similar to the Nubian sandstones. Various argillites, mudstones, and muddy quartz-felspar grits are found, some exhibiting slight results of contact alteration, due, very possibly, to the adjacent dolerites.

In the first part of the journey from near Kambia, along the Scarcies River, gneissose rocks were exposed, and at Sasseni the ancient grit, derived partly at least from old Archæan schists, and resembling, as previously stated, some early conglomerates of our own island.

The Kofiu Mountain rising to a height of 3200 feet seems to be mainly formed of gneiss, probably Archæan, capped by "undisturbed horizontal sandstones" of a Nubian type "800 feet thick." Along the upper part of the Scarcies River in Mount Jambi Buyabuya. are compact diabase, ophitic dolerite, olivine dolerite, and some sedimentary rocks. In the Talla Plateau (2000 to 3500 feet, about lat. 10° N.) igneous rocks of a basic type seem to be well developed. Dolerite apparently forms the top of the plateau for 20 or 30 miles, ending at one place in "an abrupt cliff 400 feet high." The summit of the Gonkwi Mountain (altitude 3000 feet) consists of an enstatite-dolerite with one partly spherulitic specimen; and associated with this mass and other igneous rock are argillites and gritty mudstones, some showing slight contact alteration. Near Kundita and Falaba (altitude 3500 feet, about lat. 10° N.) micaceous gneiss is common, and here also a hypersthenifeous diorite or norite occurs, containing amblystegite.

On the return journey to the coast at a point further south near Sierra Leone, some crushed specimens of schist and a mylonite, and some igneous rocks of basic or somewhat basic composition were collected. One dolerite has become a richly ferruginous and probably workable ore by the formation of iron oxide apparently replacing a pyroxene, the felspar having been replaced by a pinite-like mineral. Iron oxide frequently also is deposited in the usual way in sandstone, often forming an "iron pan" or "laterite."

Thus we find a general resemblance in many points between the rocks collected towards the extreme east and west of the African continent.[1] Above the foundation stones of gneiss and similar crystalline rock, rest the sedimentary deposits which (except the probably more ancient conglomerate and grit) seem mainly to be of the uniform Nubian type. The associated igneous rocks, whether they are intrusions or lava flows, are often lithologically similar in both districts.

[1] See also Phil. Trans. 1883, On a Collection of Rock Specimens from the Island of Socotra. Prof. T. G. Bonney. Also GEOL. MAG. 1888, Dec. III. Vol. V. p. 414, C. A. Raisin, On some Rock-specimens from Somali Land; p. 504, On some Rock-specimens from Socotra.

FIGURE 1.

Microscopic section from a small (two-inch) fragment of diorite which apparently was included within a fairly coarse granite. From Wady Halfa [113].

In the diorite, small crystals of biotite, which occur in connection with the hornblende, and imbedded in the felspar, appear to be secondary, and very possibly originated as results of the contact alteration. (Compare Q. J. G. S. 1892, vol. xlviii. p. 131, fig. 3.) See p. 438.

a. Biotite. *b*. Hornblende probably derived from an original pyroxene.

The remainder of the slide is occupied by felspar, the part marked by broken lines showing plagioclase twinning. (Magnified about 35 diameters.)

FIGURE 2.

Felstone intrusive in diorite. From near second cataract of the Nile [87]. The microscopic slide shews the junction of the two rocks, omitting towards the upper

part some of the intervening mass in order to bring more complete illustrations of both specimens within a small diagram. The felstone (on the *left* of the figure) exhibits micrographic structure sometimes developed around nuclei of kaolinised felspar. The diorite (on the *right* of the figure) shows a greenish altered mineral, and felspar crystals in which a clear zone surrounds a kaolinised interior (see p. 438).

a. Greenish mineral, partly biotite, partly hornblende.
c. Felspar crystals with kaolinised interior.
Iron oxide, only some of which is shown.
(Magnified about 30 diameters.)

III.—The Upper Devonian Fishes of Ohio.

By Prof. E. W. Claypole, B.A., D.Sc. (Lond.), Buchtel College, Akron, Ohio, U.S.A.

UNDER the true Carboniferous strata of Ohio, that is below the base of the Berea Grit, lies a mass of shale of varying colour many hundred feet in thickness. The uppermost fifty or sixty feet are often red or reddish, and have been separated with the name of the Bedford Shale. The next layer, of about the same thickness, is usually black or at least very dark and bears the name of the Cleveland Shale. Below this again is a greenish mass 500 feet or more in thickness, known as the Erie Shale. Another dark bed follows—the Huron Shale—beneath which is the great limestone base of the Devonian in Ohio, the Corniferous.

The Upper part of this great shaly mass has been variously classed with the Carboniferous and the Devonian, according to the knowledge and the opinions of the writers. It is most accordant with fact to regard it as the representative of a period of transition between these two eras, inasmuch as there is no physical break to be detected generally in the field, and, as will presently be shown, no line can be drawn in the palæontological record. We have here, as in some other places, an uninterrupted series of strata filling the interval between the two series, and were the palæontological record as full as the stratigraphical, important connecting links would doubtless be discovered.

But unfortunately the story of life is very incomplete. The shales are usually barren. The Red Bedford has yielded few traces of life except in its lowest bed, and even there they are not abundant. Still the few Brachiopods that have been found imply strong Carboniferous affinity. Some of them are:—

Syringothyris typus, Win.
Orthis Michelini, Lev.
Spiriferina solidirostris, White.
Macrodon Hamiltoniæ, Hall.
Chonetes Logani, Hall.
Lingula Cuyahoga, Hall.

The Black Cleveland Shale next below, with which this paper will chiefly deal, was for many years a barren ground to palæontologists. Nothing at all had been found in it; but recently and locally it has proved to be a rich storehouse of fossil fishes of new and strange types. But these are all, except now and then, a fragment of fossil weed (Dadoxylon) or more rarely still a broken and crushed molluscan shell such as *Eodon bellistriatus* or a closely allied form.

From this shale have come almost all the known species of

Dinichthys, all those of *Titantichthys*, and the single specimen of *Gorgonichthys* yet found (see American Geologist for 1892). These monsters paralleled in form and size those which tenanted the seas of Europe in the late Devonian days, and with some of which the name of Hugh Miller is inseparably connected.

All these, by name at least, are now familiar to the palæontologist chiefly through the classic writings of Dr. Newberry. But since his time further research has brought to light a new fish fauna from these shales of equal interest but of very different nature.

For some years a few scattered Cladodont teeth have been known from the shales of Ohio. Five species in all were given by Dr. Newberry in his contribution to the Palæontology of Ohio (vol. ii. p. 46, etc.). These are:—

C. subulatus, Nby., Cuyahoga Shale.
C. concinnus, Nby., Cleveland Shale.
C. Hertzeri, Nby., Bedford Shale.
C. parvulus, Nby., Cleveland Shale.
C. Pattersoni, Nby., Berea Shale.

Of these the first and last belong above the Berea Grit in undoubted Carboniferous territory and need not be further noticed. The other three constitute all our knowledge of the Cladodonts of Ohio from rocks older than the Berea Grit until quite lately.

Nor was anything more known of this family in the Old World. The European Devonians, with all their wealth of fish fossils, are almost as poor in the evidence which they afford us of the existence of Sharks as the coeval strata in America, while of the Cladodonts in particular they tell us almost nothing.

And when we turn and ask what we really know of these fishes from other and later strata we find our ignorance oppressive. Teeth of Cladodonts abound in the Carboniferous rocks, and spines, supposed rightly or wrongly to belong to them, are also not scarce. But of the fish themselves that bore these weapons, we knew a few years ago absolutely nothing.

The first glimpse which we obtained of the body of a Cladodont Shark was that of a broken and incomplete relic, described by Dr. Traquair in the Geological Magazine for February, 1888. Only the fore part of the fish was there. It had been pieced together, and some doubt existed if all the fragments belonged to the same specimen. A part of the head, with true Cladodont teeth, a fin, and a mass of "crushed and inextricably confused cartilages," formed the unpromising material from which it was the task of the palæontologist to try to restore to order. It gave us a glimpse and nothing more.

In the following year appeared Dr. Newberry's great "Monograph of the Fossil Fishes of North America," in which he, for the first time, figured nearly the whole of a *Cladodus* from the Black Shale, under the name of *Cladodus Kepleri*, and a second, less complete, as *C. Fyleri*. Here we had for the first time an opportunity of forming an approximately adequate conception of the size and shape of these ancient sharks. But the specimens at Dr. Newberry's command were not good enough for full and exact specific description.

It is a little surprising that at last the material for enabling us further to realize our picture should have come from these long-called barren shales of Ohio. But during the past two years an enthusiastic and patient collector, Dr. Clark, has brought to light a number of specimens in a wonderfully good condition considering the pyritized state of all the fossils from this stratum. By dint of great labour he has so far cleared them from the matrix that I have been able to describe at least five species in addition to the one figured by Dr. Newberry. The details may be found in the American Geologist for May, 1893. It is not my intention here to dwell upon the specific distinctions of these fishes, but to point out a few interesting facts and inferences in the palæontological history o the Cladodonts.

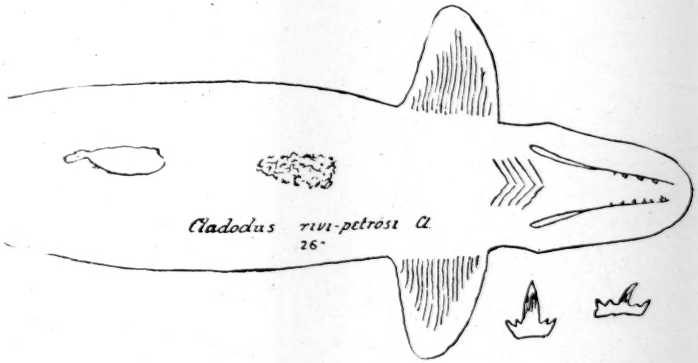


FIG. 1.—Head, pectoral fins, and abdominal region of *Cladodus rivi-petrosi*, Claypole; with two teeth enlarged.

The figures given herewith will enable the reader to form some idea of their general shape, at least as they are preserved in the fossils. All the specimens yet discovered present either the dorsal or the ventral aspect, in almost all cases the latter. The Shark apparently settled down in that position on dying, perhaps owing to the accumulation of gases in the abdominal region.

The most obvious unusual feature is the expansion of the head. This is so much wider than the body that the fish appears to have a neck in some cases, as in *C. sinuatus*, etc. In others the constriction is less, while in some it is almost absent. The suspicion is of course aroused that it may be a result of something in the process of fossilization, but an examination of the specimens renders this unlikely. It is not, apparently, due to pressure or distortion.

Among existing Sharks it is not easy to find any structure that when fossilized would show a similar form. But the Bonnet Shark, or the Shovel-nosed Shark (*Reniceps tiburo*), may be quoted as an illustration of a fish that in outline, as seen from above, might produce an impression resembling the one in question. On a side

view this shark shows the ordinary inferior mouth and sharp snout of the family. But its head is extended laterally into a thin, sharp-edged flange, on the margin of which are set the eyes. This flange suddenly terminates backwards, its edge turning in at right angles to the axis of the body. Its dorsal aspect consequently presents a head twice as wide as the body and semicircular in outline at the front. Such a form may without much effort of the imagination be compared with that of the Cladodonts (see Fig. 1).

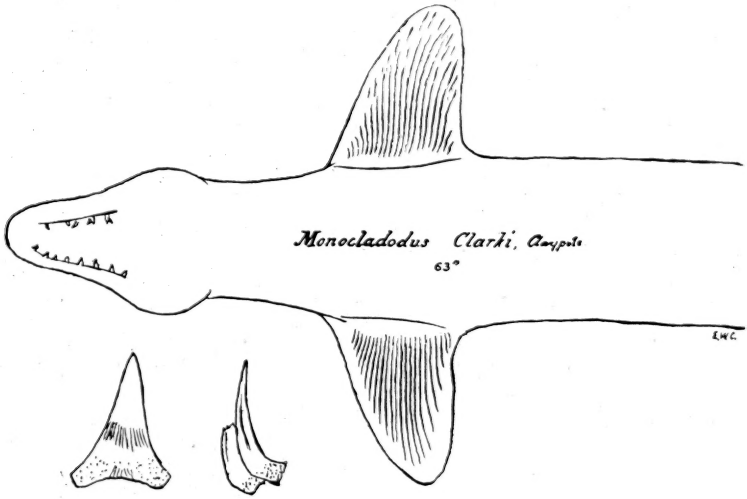


FIG. 2.—Head, pectoral fins, and abdominal region of *Monocladodus Clarki*, Claypole; with teeth enlarged.

A yet more singular expansion of the head occurs in the Hammer Shark. But the great lateral extent in this fish is less suggestive of the head of these Cladodonts than is that of the Bonnet Shark.

It is not my intention here to imply that any close affinity existed between this fish and the ancient Cladodonts. This may or may not have been the case. Animals far asunder in our system frequently simulate one another's form, so that no argument can be drawn from mere external similarity. The condition of these pyritized fossils prevents for the present any detailed study of their structure.

In one or two species there is a remarkable expansion of the skin or some membrane as a horizontal flap just in front of the caudal fin. I know no analogy that exactly meets this structure. Nor can I assign a use for this organ. In one or two specimens it is exceedingly well-preserved. In other species it may have been absent, or is concealed or destroyed. The tail and adjacent parts are frequently in bad condition. The flap shows no rays or markings of any kind. It was not covered with shagreen and was evidently quite soft. It

seems to have no analogy with the flattening of the body that is characteristic of the skates and rays.

So far as it is possible to determine from the specimens thus far found, no spines were present anywhere on the fish. On this point the position of the fossils leaves little room for doubt. In view of the identity that has been suspected between the Cladodonts and Ctenacanthus this point is of considerable interest. The dorsal fins are not clearly shown even in those specimens which are lying on their ventral faces, but it is scarcely possible to believe that had a spine in any degree resembling *Ctenacanthus* been present its mark or its cast must somewhere have been visible. Dr. Traquair evidently inclines to this view. In the GEOLOGICAL MAGAZINE for February, 1888, he says, "No spine is visible on the East Kilbride *Cladodus* but the body is mostly absent." "In the Eskdale *Ctenacanthus*, though I interpreted its one imperfect tooth as Cladodont, I am willing to leave that an open question." "The teeth found associated with *Ctenacanthus hybodoides* are allied to *Hybodus*. It has nothing to do with *Cladodus*."

In addition to all this the evidence of the Ohio specimens seems conclusive that *Cladodus* was a spineless Shark, whether closely allied to *Chlamydoselachus* or not. The spines, therefore, that occur in the Devonian rocks must be assigned to some other fish. *Ct. vetustus* of the Cleveland Shale and *Ct. Wrighti* of the Hamilton remain unappropriated.

Another point worthy of notice is the skin of these Cladodonts. This on the dorsal surface shows no difference from ordinary shagreen. The minute dermal ossicles are smooth, showing in most cases little or no sign of sculpture, though occasionally traces of a pattern may be seen; but on the ventral surface this shagreen is absent, and thin rhomboidal scales supply its place, reminding one very much of ganoid plates of great tenuity. These are arranged in diagonal lines across the lower surface, exactly as are those of a Gar or other ganoid fish. Dr. Newberry has indicated this character in his figure, and it is much more evident in some of the recently found specimens: apparently it is common to them all.

In regard to the pectoral fins, the evidence is obscure in spite of the apparently excellent state of preservation. There is no trace of a median axis or of two rows of rays. The fin is consequently not archipterygial in type, and the Cladodonts, therefore, if retained among the *Ichthyotomi* must be considered abnormal. Only a single row of fin-rays is present and the basal cartilages on which they are set are concealed in the pyritous mass to which the body in general is reduced. The full description of the fins must therefore await the results of future discoveries.

The position taken at the outset that the Cleveland Shale is intermediate between the true Carboniferous rocks above and the true Devonian below will be justified when we consider the strange assemblage of fishes whose remains have come to light from this stratum. The great Placoderms, *Dinichthys*, *Titanichthys* and *Gorgonichthys* are essentially Devonian in type, and are the analogues

of the armoured fishes of the Old Red Sandstone of Scotland and of other parts of Europe. On the other hand, the Cladodonts are almost as essentially Carboniferous in aspect, or at least have hitherto been so considered. The presence of *Coccosteus*, it is true, gives an air of antiquity to the fauna by its strong Devonian affinity. It is, however, in Ireland and Canada an Upper Devonian genus. On the other hand, a small ganoid seen in a macerated condition in the stomach of the Cladodont *C. rivi-petrosi*, and shown in our Figure, though incapable of exact interpretation, suggests *Palæoniscus*.

Beyond question we have in this shale a stratum which records a transition time. The canons of palæontology must be very freely interpreted to allow of such a confusion of species. But this is only what we look for with advancing knowledge. All the hard and fast lines between our little systems must be blotted out, and the record of life becomes one continuous story before the tale of the rocks is fully told.

It is scarcely too much to assume that in the Cleveland Shale we shall have preserved for us in its hard, tough concretions the history of a quiet time and a quiet area, where the Devonian fishes lived on and the Carboniferous forms developed by their side. The Cladodonts no longer burst upon us in full splendour with the Mountain Limestone, but we find them abundant long ages before the time of its deposition, living side by side with *Coccosteus*. To discover their origin and their ancestors we must go further back and seek their remains in lower and older strata.

General Section in N.E. Ohio.

		Feet.
Carboniferous	Carboniferous Conglomerate (Millstone Grit)	250
	Lower Carboniferous Limestone (Mountain Limestone)	0
	Logan Group	0
	Cuyahoga Shale	250
	Berea Shale	20
	Berea Grit	50
	Bedford Shale (often red)	50
	Cleveland Shale (dark or black)	60–20
Devonian	Erie Shale (greenish)	3000-0
	Huron Shale	not cropping out at surface.
	Hamilton Shale	
	Corniferous Limestone	

IV.—On the Origin of the Engadine Lakes.

By C. S. Du Riche Preller, M.A., Ph.D., Assoc.M.I.C.E., F.C.S., F.G.S.

ANY geologist who, in these days, is still bold enough to affirm that the origin of Alpine Lakes generally is due to glacial erosion, must surely derive considerable comfort from a visit to the Upper Engadine; for the four lakes which adorn that valley appear, at first sight, to constitute so many typical examples of the erosive power of the ancient Inn glacier, and therefore a striking confirmation of that time-honoured theory. A closer and more extensive examination of the physiography of that exceedingly interesting district, leads, however, as in so many similar cases, to a very different, and precisely opposite conclusion.

In following the gently ascending Upper Engadine Valley from Samaden, situated below the outflow of the river Inn from the last, viz. the St. Moritz Lake, the valley at the Upper or Maloja end seems to be closed in by an imposing chain of mountains in which that river may naturally be supposed to rise. But the peculiar feature of the district consists precisely in this, that what above the uppermost, viz. the Sils Lake is locally, and also in text-books, termed the "Inn," is a mere insignificant stream which rises only about a mile higher up, in the small lake of Lunghino, situated at an altitude of 2408 metres, 1900 feet above sea-level, or about 2000 feet above the Sils Lake. This is at first the more puzzling, because the locality of Maloja forms an alluvial plain which is evidently the remains of a former river bed of considerable extension. The fact is that there really exists now no individual river Inn as feeder of the four lakes, and that the Inn of the present day, as known in the Lower Engadine, only begins at Samaden after its confluence with the Bernina, and *per se*, is nothing but an agglomeration of Alpine torrent falling into the lakes between that village and Maloja. The sources of the ancient river Inn which was powerful enough to erode and form the Engadine valley, only become apparent when we go beyond, viz. south of Maloja. As is known to every one who is familiar with the district, the Plain of Maloja is a depression between two parallel mountain ranges trending S.W. to N.E., which divides the present watersheds of the Inn and Meira systems, and forms the summit of the Pass of the Alpine route from Chiavenna to the Engadine. Immediately after Maloja, the ground takes a sudden plunge of 250 metres or of about 800 feet at an angle of 45 degrees into the so-called Bargaglia valley and thence falls rapidly to Chiavenna. But if we examine the watercourses immediately south of Maloja and descending into the Bargaglia valley, we are confronted by the remarkable phenomenon that several of the principal glaciers and torrents emerging from them, run in a north-easterly direction, and that after a certain distance the torrents suddenly turn south-west at a sharp angle. Thus, the Meira or principal river of the Bargaglia valley, takes from the confluence of its two branches below the Septimer Pass at an altitude of 2000 metres or about 6600 feet, a north-easterly course through the Marozzo valley, in the direction of Maloja, until after a run of about 2800 metres, it describes a curve to the S.W., and enters the Bargaglia valley near Casaccia, about two miles below Maloja. On the opposite side of the valley the case is even more striking. From the Forno glacier trending N.E., emerges at an altitude of about 2000 metres, or 6600 feet, the Orlegna, which flows in the same N.E. direction, until close to, and practically on a level with Maloja, it deviates by a sharp curve to S.W., and following the foot of the wall dividing the watersheds, flows into the Meira below Casaccia. No less remarkable is the course of the Albigna, which after emerging from the glacier of the same name at an altitude of 2064 metres or 6800 feet, keeps for about a mile the same direction as the glacier, viz. N.E. parallel to that of the Forno, and more or less in the

direction of Maloja, where it suddenly turns S.W., at an angle of 50 degrees, and flows into the Meira near Vicosoprano. The course of these two rivers and that of their glaciers runs parallel to all the tributaries of the Upper Engadine lakes, such as those of the Val Fedo, the Val Fex, the Bernina, and others, whilst the Meira in its upper course runs parallel to the Julier and St. Moritz torrents and the smaller tributaries of the lakes on the other side of the Engadine valley. Below Vicosoprano, all the torrents run more or less at right angles to the Bargaglia valley, viz. they follow a normal course.

We have, thus, the three principal rivers of what is now the Bargaglia valley, viz. the Meira, the Orlegna, and the Albigna,—the two last named with their glaciers—rising at much the same altitude, viz. about 7000 feet and pointing in their upper courses in the direction of Maloja, or North of the Alps, while in their lower courses they are deflected to the S.W., or South of the Alps. It follows that these three rivers were the principal tributaries if not the actual sources of the ancient Inn, the confluence of the three being at Maloja, as is evidenced by the large superficial area of that plain which first formed a trough and was subsequently filled up by the deposits of the three rivers. The distance from the points where the rivers, the Meira, Orlegna and Albigna rise, to the ancient Maloja confluence is six, four, and eight kilometres, and the fall at the rate 3·6, 4·4, and 3·2 per cent. respectively, which is practically the same as that of the two principal tributaries of the Sils and Silvaplana lakes, the Fedo and the Fex of 3·6 per cent. The crest line of the old divide of the Engadine and Bargaglia river systems was therefore fully six miles south of Maloja, and stretched almost at right angles across the present Bargaglia valley near Vicosoprano; for it is on a line drawn from the Pizzo della Duana (3133 metres) to the Cima Bondarca (3288 metres) that we strike on one side the sources of the Meira, and on the other, the upper terminals of the Albigna and Forno glaciers from which emerge the Albigna and Orlegna, all trending N.E., whilst to the south of this line of demarcation the valleys trend distinctly in the opposite direction. Not improbably from the central part of this old divide whose crest line was at about 3000 metres altitude, there descended to the north a glacier which was one of the main spings of the old Inn, and whose torrent joined the other three at Maloja.

In Prof. Heim's opinion, the remarkable deflection from north to south of these three torrents, viz. the Meira, the Albigna and Orlegna, was brought about by the greater erosive power of the torrents descending on the south of the Vicosoprano crests line into the Bargaglia valley, whereby the divide was gradually scooped out, worn down, and pushed back until the valley receded to above Casaccia and below Maloja, viz. to the present divide.[1] But this

[1] Swiss Alpine Club, 1879–80.—When Prof. Heim attributes the receding of the valley and of the divide to the backward erosive action of the Meira, it is not very clear whether he refers to the principal torrent south of the old divide, or to the Meira of the present day, the former tributary or one of the sources of the Inn. If the former, it would not be the Meira at all; if the latter, the Meira assuredly could not run and erode to the south until the old divide had disappeared. In the meta-

hypothesis appears untenable, when it is considered that as long as the divide of Vicosoprano existed, the principal river of the then Bargaglia valley and its tributaries must have been very insignificant, and their erosive power, in spite of their great fall, quite insufficient to excavate backwards, even to the Albigna, a mountain barrier 6600 feet in vertical depth and composed, like the massifs of the Bargaglia and Engadine ranges generally, of granitic gneiss, and hornblende schists. The deflection of the Meira, Albigna, and Olegna from their former course can only have been produced in the first instance by a subsidence of the old divide, whereby a basin or trough was formed between Vicosoprano and Maloja, and the three powerful torrents now turning to the south, and gaining considerably in fall were able to erode the remainder of the divide at Vicosoprano and form the Bargaglia valley of the present day. The subsidence and consequent formation of the Casaccia trough is attested not only by the general configuration of that trough and by the defile of Vicosoprano, but also by the quasi-perpendicular wall or drop of 800 feet immediately below Maloja, no less than by the Albigna which in its upper course of about a mile, viz. before its deflection to the south, now falls from 2000 to 1200 metres, equal to a fall of no less than 34·6 per cent. or more than ten times its old fall to the Engadine. The erosive action of the rivers and torrents below as well as above Vicosoprano was therefore only the secondary cause, the primary cause being a subsidence; and this explanation tallies, moreover, remarkably well with Professor Heim's own and latest views with regard to the origin of the principal Alpine lakes as the effect of a subsidence of the massif of the Alps between the first and second glacial epochs, to which views I propose to refer in a future communication.

The effect of the deflection of the original sources of the Inn system to the south, by which the Upper Engadine valley was deprived of its principal agents of erosion, was the gradual formation of the Sils, Silvaplana, Campfer, and St. Moritz lakes. From a powerful Alpine river, the Inn at Maloja was reduced to a small torrent which had neither sufficient volume nor sufficient fall to wash out and carry away the deposits brought down by lateral torrents between Maloja and Camadon; hence these deposits filled and raised its bed, and thus the lakes whose average depth is about 350 feet were formed by the weakened river being banked up at various points.[1] Thus the deposits of the Val Fex torrent banked

phorical phraseology in which he delights, that distinguished geologist speaks of the "tremendous fight between the Meira and the Inn which ended not only in the complete discomfiture of the latter but also in the Orlegna and Albigna forsaking their old allegiance." It is difficult to see how there could be a fight, because—to follow up the metaphor—the Inn was simply a passive looker-on, and the Meira and the other two rivers turned naturally to the south when an opening was made for them, giving them a greater fall.

[1] From measurements made by the writer the combined drainage area of the Meira, Orlegna, and Albigna within the old (Vicosoprano) divide, is about 120 square kilometres (44 square miles); that of the four lakes from the present (Maloja) divide to the lower end of St. Moritz lake is 140 square kilometres (51 square miles); and that of the present Inn torrent rising in the lake Lunghino, is 16 square

the river at Sils, forming the Sils lake, while this, the largest of the Engadine lakes, will at no distant time be itself divided into two by the débris-cone of the Val Fedo torrent, which cone is gradually stretching across to the rocky spur on the other side. The next two lakes, that of Silvaplana and Campfer, were originally one, being formed by the deposits of St. Moritz torrent at Campfer, and were subsequently divided by the Julier torrent at Silvaplana. The St. Moritz lake alone presents somewhat different conditions, the bar being in this case not alluvial but older deposit rising above the lake level to a height of about 500 feet, through which the river has cut as yet only a narrow channel or rapid of one kilometre in length, having a total fall of 43 metres or 4·3 per cent. viz. ten times the fall and mechanical energy of the upper course. But it is only near Samaden that the Inn, by the addition of the Bernina and Val Roseg torrents, having a drainage area of 200 square kilometres and a volume of 13 cubic metres or tons per minute becomes a true Alpine river and then attains sufficient volume and fall (22 cubic metres or tons per minute) to cut through and wash away the lateral deposits, to exert its erosive energy to its full extent, and thus to prevent the formation of lakes further down the valley.

The hydrographic changes brought about, in the first instance, by the subsidence or dislocation of the old divide of the Inn and Bargaglia systems, and by the consequent deflections to the south of the original Inn sources, are the more striking when we consider the enormous difference between the fall of the two river systems North and South of the Alps respectively. The entire course of the Inn from Maloja (1810 metres) to its confluence with the Danube at Passau (290 metres), where in volume it greatly exceeds the latter, is 400 kilometres or about 250 miles, the average fall being therefore at the rate of 0·4 per cent., whilst in the Upper Engadine from Maloja to Samaden, a distance of about 16 miles, the fall is 100 metres, or 0·4 per cent., viz. not above the average. The Meira, on the other hand, has from Casaccia (1460 metres) to Chiavenna (317 metres) in a distance of 22 kilometres or 14 miles a fall of no less than 1143 metres or 5·5 per cent., viz. more than ten times

kilometres (six square miles). Taking the rainfall in those Alpine valleys at 2·5 metres per annum, less 25 per cent. for absorption and evaporation, or in round figures at 2 metres (6·56 feet), the quantity of water of the three drainage areas respectively worked out as follows:

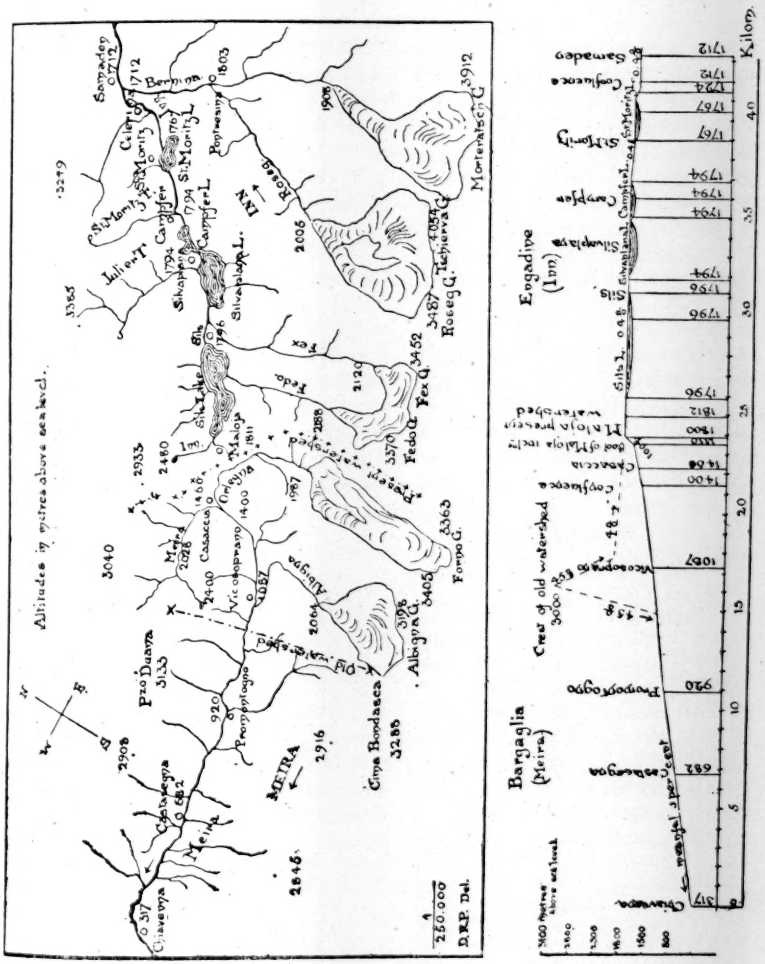
Meira, Orlegna, and Albigna, $\frac{120 \times 1{,}000{,}000 \times 2}{365 \times 24 \times 60} = 438$ cub. metres or 15,460 cub. ft. per min.

Up. Engadine lakes, $\frac{140 \times 1{,}000{,}000 \times 2}{525{,}600} = 533$,, ,, 18,820 ,, ,,

Inn torrent, $\frac{16 \times 1{,}000{,}000 \times 2}{525{,}600} = 69$,, ,, 2,440 ,, ,,

The old Inn carried therefore, at the present outflow of the St. Moritz lake, about 1000 cubic metres or tons per minute, which quantity the deflection of the Meira, Orlegna and Albigna reduced to about one half, whilst the present Inn at Maloja only carries about one-sixth of the volume of the old river, the erosive power being reduced in the same proportion.

that of the Inn; the erosive energy it developes being in direct proportion to its volume and fall; whilst its velocity is, of course, the greater the more confined is its bed. As has been shown, it is the loss of that erosive agency and energy in the Upper Engadine by the deflection to the south of the old Inn sources that has led to the formation of the four lakes; in other terms they owe their origin to the slackening and partial stoppage of fluvial, but never to glacial erosion.



V.—Note on the Growth of Lake Geneva.

By Charles Davison, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

THOUGH the observations described in this note are not conclusive, they seem to me to show that the lake of Geneva is probably growing at the present time, and that a similar growth, if taking place beneath an ice-covering[1] on nearly level ground, would in time produce a true rock-basin. Unfortunately, the instruments used were very delicate levels, and experiments with such instruments prove that they are not to be trusted entirely for measurements of very small angles continued over a long interval of time.[2]

The observations referred to were made for several years by M. Ph. Plantamour at Sécheron, near Geneva. I have given some account of them in a former paper,[3] and will now only repeat those particulars which bear immediately on the present subject.

Sécheron lies on the west shore of the lake, about a mile and a quarter north of the observatory of Geneva. The shore-line here runs about 30° E. of N. and 30° W. of S. and the slope of the ground must be roughly in a direction at right angles to this, *i.e.* about 30° S. of E. One of the levels is placed east and west, the other north and south. They show that, from day to day, the inclination of the ground which forms the floor of M. Plantamour's cellar is incessantly changing. The most noticeable movements are periodic, and are clearly caused by the annual and diurnal changes of external temperature. But we can eliminate these very nearly by calculating the average inclination throughout the year towards the east and north. This is done in the following table for the third to the eighth years, reckoning the average inclination during the third year as zero :—

		East.	North.
3rd year (Oct. 1, 1880—Sept. 30, 1881).	...	0″	0″
4th ,, (,, 1881— ,, 1882).	...	5·55	1·11
5th ,, (,, 1882— ,, 1883).	...	5·07	2·92
6th ,, (,, 1883— ,, 1884).	...	11·66	3·82
7th ,, (,, 1884— ,, 1885).	...	18·82	5·60
8th ,, (,, 1885— ,, 1886).	...	16·99	7·60

The inclinations during the first year are omitted because the N.S. level was not placed in position until nearly three months had elapsed; and those of the second year, on account of an unusually great movement in a direction somewhat south of east, which, of course, affected the readings of both levels. After the eighth year the N.S. level was removed and placed in an E.W. direction nearer

[1] See Prof. Judd's paper "On the Origin of Lake Balaton, in Hungary," Geol. Mag. Vol. III. 1876, p. 12.

[2] If similar observations were made for a few years in different parts of Switzerland with a suitable instrument, such as the horizontal pendulum of Dr. E. von Rebeur Paschwitz, or the bifilar pendulum of Mr. Horace Darwin, the labour and money spent would meet with a rich reward. In this country observations of great interest might be made near the north-east end of Loch Ness, say at Aldourie or Dores.

[3] Phil. Mag. Vol. xxvii. 1889, pp. 189–199.

the middle of the house. The result of this change was to show, I believe, that the periodic movements indicated by the E.W. level may in part arise from bendings in the walls of the house, caused by the expansion and contraction of the roof.

Referring to the above table, it will be seen that the inclination towards the east changed rather irregularly, in three years being considerable and in the other two slightly retrograde. During the second year of the observations there was an extraordinary movement of $1\frac{1}{2}$ minutes between Nov. 13, 1879, and Jan. 28, 1880, in a direction a little south of east. The masonry on which the levels rested is not, however, totally disconnected from the structure of the house; and it seems to me most probable that the non-periodic movements indicated by the E.W. level are due to a settling of the house in the line of greatest slope of the ground outside.

On the other hand, the change of inclination towards the north has taken place much more regularly, the annual change varying from 0″·90 to 2″·00, and being 1″·52 on an average for the five years.[1] So far as I am aware, there is nothing of a purely local character to account for this movement. It seems to be independent, or nearly so, of that which takes place in an easterly direction; for it may exist without the latter. There can hardly be any creeping of the soilcap or settling of an old house along a line nearly at right angles to that in which the land dips and in reality inclining upwards. It is possible that the levels may be at fault, for, as before remarked, they are by no means perfect instruments; but the regularity of the movements is in favour of the view that they are caused by a real tilting of the ground itself, a tilting which must result in the very slow but still measurable growth of the Lake of Geneva.

VI.—The Geological Development, Descent and Distribution of the Mammalia.

By Prof. Karl A. von Zittel, Ph.D., For. Memb. Geol. Soc. Lond.

Professor of Palæontology in the University of Munich.

(*Continued from page* 412, Vol. X. September, 1893.)

In addition to the localities in Europe and N. America, another area for Tertiary Mammals has in very recent times been laid open to view in the Southern part of Argentina, which promises in the wealth of its contents to exceed those previously known. A few scattered remains from the Tertiary beds of the neighbourhood of Santa Cruz in Patagonia were already known more than forty years ago, but it is only lately, through the work of Burmeister and Moreno, and more particularly through the indefatigable researches of Florentino Ameghino, that a more complete insight into this very remarkable fauna has been obtained. It is imbedded in fresh-water

[1] If this rate were to continue uniform, a change of inclination of ten degrees would be produced in 23,684 years. The rate is, however, probably greater than this; for, since the ground slopes in a direction south of east, movements in this direction affect the inclination of the N.S. level.

deposits, from 60 to 80 mètres in thickness. The following genera are known up to the present from the Santa Cruz Formation:—

MARSUPIALIA.
Eodidelphys.
Prodidelphys.
Microbiotherium.
Stylognathus.
Hadrorhynchus.
Prothylacinus.
Perathereutes.
? *Borhyæna.*
? *Acrocyon.*
? *Agustylus.*
? *Hathlyacinus.*
? *Dinamyctis.*
? *Conodinyctis.*
? *Anatherum.*
? *Sipalocyion.*
? *Acyon.*
? *Ictioborus.*
? *Cladosictis.*
? *Protoproviverra.*
Abderites.
Acdestis.
Decastis.
Epanorthus.
Callomenus.
Halmadromus.
Halmaselus.
Essoprion.
Pichipilus.
Garzonia.
Halmariphus.

EDENTATA.
a. Vermilinguia.
Scotæops.
b. Tardigrada.
Entelops.
Didetilotherium.
c. Gravigrada.
Zamicrus.
Hapalops.
Pseudhapalops.
Amphihapalops.
Schismotherium.
Trematherium.
Nematherium.
Geronops.
Analcimorphus.
Eucholœops.
Hyperleptus.
Xyophoros.
Planops.
Paraplanops.
Metopotherium.
Eurysodon.
Tolmodus.
Prepotherium.
Lymodon.
Analcitherium.
Ammotherium.

d. Glyptodontia.
Cochlops.
Eucinepeltus.
Propalæohoplophorus.
Asterostemma.

e. Dasypoda.
Dasypus.
Chlamydotherium.
Peltephilus.
Stegotherium.
Prozædyus.
Proeutatus.
? *Antiosodon.*

PERISSODACTYLA.
a. Proterotheridæ.
Diadiophorus.
Licaphrium.
Thoatherium.
Proterotherium.

b. Macrauchenidæ.
Theosodon.
Cœlosoma.
Pseudocœlosoma.

TOXODONTIA.
Nesodon.
Adinotherium.
? *Gronotherium.*
? *Xotoprotodon.*
? *Acrotherium.*
? *Phobereotherium.*
? *Nannodus.*
? *Rhadinotherium.*
? *Palæolithops.*
Astrapotherium.
? *Listriotherium.*
? *Astrapodon.*
Homalodontotherium.
? *Diorotherium.*
Colpodon.

TYPOTHERIA.
Protypotherium.
Patriarchus.
Interatherium.
Icochilus.
Hegetotherium.

RODENTIA.
Steiromys.
Acaremys.
Sciamys.
Scleromys.
Adelphomys.
Stichomys.
Olenopsis.
Spaniomys.
Neoreomys.
Hedimys.
Phanomys.
Eocardia.
? *Procardia.*
? *Dicardia.*
? *Tricardia.*
Schistomys.
Sphæromys.
Sphodromys.
Sphingomys
Perimys.
Pliolagostomus.
Prolagostomus.
Lagostomus.
Scotoeumys.

PRIMATES.
Homunculus.
? *Homocentrus.*
Anthropops.
? *Eudiastatus.*

The composition of this Patagonian Tertiary fauna, which according to Ameghino is preceded by some older mammalian remains, intermingled with some probably Dinosaurian and Crocodile bones, stands in the strongest contrast with the Mammalia occurring in the Eocene of Europe. Of the 121 genera introduced above, with at least 220 species, a notable proportion will very likely not stand critical examination, but in any case the fossil mammalian fauna of Santa Cruz notably exceeds, in its wealth of genera and species, that

now existing in Argentina, which according to Ameghino only contains 107 species, and it is in this point of view equally comparable with that of the Upper Eocene of Europe. Ameghino increases the list further by three alleged Amblypoda (*Planodus*, *Adelotherium*, *Adrastotherium*) and a Tillodont (*Entocasmus*), but these additions are based on remains which absolutely do not permit of satisfactory determination. In comparison with the Europeo-American Eocene fauna, the complete absence of the Artiodactyla, Insectivora, Chiroptera, Carnivora and Prosimiæ, is very striking. The Perissodactyla are represented by two entirely novel extinct families (Proterotheridæ and Macrauchenidæ); the Rodents entirely by Hystricomorphous forms of a specifically South American type, and equally so the Primates by the Platyrhine Apes. The fauna is mainly composed of Marsupials, Edentates, Toxodonts and Typotheria. Only South America possesses representatives of these two last orders, which make their appearance in the Santa Cruz formation and become extinct in the Pampas formation. Also all the forms of Edentates belong to the Xenarthra, which now live exclusively in South America, and amongst the Marsupials, the most prominent are the Didelphyidæ, which still live all over America and in the Tertiary period were distributed over the Northern hemisphere, but these are accompanied by other forms of the same order which show an Australian stamp. Ameghino has placed these in part with the Dasyuridæ and in part with the Creodontia, but as regards the last he is now himself doubtful, and acknowledges[1] that a part at least of the supposed Creodontia may belong to the Marsupials. The same may be said of the supposed Plagiaulacidæ, on which Ameghino had mainly relied to determine the age of the Santa Cruz formation.[2] These also probably form an independent family of Marsupials, either indigenous or possibly migrated from Australia.

Under any circumstances South America must be considered as an independent "centre of creation," which possibly at an early period had been ingrafted from Australia, but which already in the Santa Cruz formation had produced peculiar forms of Marsupials. In favour of a connection with the mammalian fauna inhabiting Europe and North America at the same time, there is, in spite of the assurances of Ameghino, no ground of support. On the other hand it cannot be denied that there is some authority for the supposition of Ihering, based on the distribution of the fresh-water animals, that South America, during the Mesozoic and Older Tertiary periods, was connected by land with Australia and South Africa. The associated

[1] Revista Argentina, I. p. 314.

[2] The examination of a great number of lower jaws and detached teeth of the genera *Abderites*, *Acdestis* and *Epanorthus*, which I owe to the kindness of Señor Ameghino, shows that the molars in these genera do not agree, either in number or in form, with those of *Neoplagiaulax*. They greatly resemble those of the Australian Hypsiprymnidæ, and they are proved to be genuine Marsupials by the incurved angle of the lower jaws. Ameghino also acknowledges them (Revue génér. des Sciences, 1893, p. 77) as Diprotodont Marsupials, to which he also further assigns *Plagiaulax*, *Neoplagiaulax* and *Ptilodus*.

group of animals which the investigations of Ameghino has brought to light in Patagonia is new and altogether peculiar, and in it are to be found the ancestors of the Edentates, Rodents and Apes of the present neotropical kingdom.

There are great difficulties in the way of precisely determining the age of a fauna thus new and circumscribed, more particularly since the geological relations do not yield any definite information. The Santa Cruz beds rest directly on the "Guaranian formation," the lower portion of which consists of marine deposits, undoubtedly belonging to the Cretaceous; whilst the upper consists of conglomerates and coarse sandstones, in which the remains of Opisthocœlous Crocodiles and Dinosaurs (?) and the imperfectly preserved mammalian fragments mentioned above (*Macropristis*, *Pyrrhotherium*, etc.) have been discovered. The Santa Cruz formation is overlaid by flows of Basalt, and it forms the foundation for the marine deposits with *Ostræa Patagonica*, *Pecten Paranensis*, and a great number of other fossil shells which have been already examined by D'Orbigny, Darwin and Bravard, and determined to be Tertiary. Darwin held the marine deposits to be Eocene, D'Orbigny, Miocene, and Ameghino, Oligocene. Direct points of comparison with North American or European Tertiary strata are here also wanting, so that the age of the Santa Cruz and Patagonian formations must be wholly determined from the general character of the fossil remains.

Ameghino places the mammalian fauna of Santa Cruz in the Eocene. That, however, the existence of Amblypoda, Tillodontia, Creodontia, and Plagiaulacidæ cannot be advanced in favour of this view, has already been mentioned. Amongst the Marsupials, forms of a distinctly ancient stamp are wanting, and in particular one fails to find close ties to the Mesozoic Polyprotodontidæ and Allotheria. Amongst the Perissodactyla, the Macrauchenidæ stand on a primitive rank as regards their dentition and the structure of their extremities, when compared with their later successors in the Pampas formation; on the other hand the Proterotheridæ, which, as regards their dentition, may be the most readily compared with the Anoplotheridæ and Palæotheridæ, have far outran these latter in the reduction of the lateral metapodials and in the complete differentiation of the extremities. The remarkably numerous and varied Edentates do not in the least correspond with the ideas which one is justified in holding respecting the ancestors of this order. They remain, indeed, in size far behind the giant forms of the Pampas formation, but they are already just as distinctly divided into sub-orders (Vermilinguia, Tardigrada, Gravigrada, Glyptodontia and Dasypoda) as in the Pleistocene, and they stand in all the important features of the dentition and build of the skeleton, on a high grade of differentiation. The molars are already of a prismatic form, incisor teeth are only known in two genera, and a change of teeth appears to have taken place just as seldom as in the majority of living Edentates. Skull and skeleton do not materially differ from those of younger genera, and the characteristic dermal shields of the Glyptodonts and Dasypoda from the Santa Cruz formation are in reality built up like

those of Pleistocene and living genera. According to Ameghino even two existing genera (*Dasypus* and *Chlamydotherium*) make their appearance in the Santa Cruz formation. The Edentates cannot, therefore, be appealed to as witnesses for the ancient character of the fauna. Just as little can the Rodents. These also belong exclusively to Hystricomorphous forms of a specifically South American stamp, and they are in part very closely connected with genera still living or even altogether identical with them (as *Lagostomus*). Their supposed relations to the European Protrogomorpha (*Theridomys, Nesokerodon, Archæomys*) have proved deceptive, and the same is also the case with regard to the North American Tertiary Rodents. The mostly high prismatic teeth and the absence of a milk dentition are proofs that the Rodents of the Santa Cruz formation have on the whole reached a higher grade of development than their Upper Eocene relatives in Europe and North America. Amongst the Toxodonts only the Homalodontotheridæ show primitive features; all the rest have a highly differentiated dentition, mostly prismatic molars and reduced extremities. In the Typotheria the generally closed rows of teeth and the five-toed extremities betray a more primitive condition than in their successors of the Newer Tertiary and of the Pampas formation, but even in this group the curved molars have already reached a prismatic form. Finally, the Apes can in no wise be considered as the stock from which all our present Simiæ have descended, for they have a definite South American stamp, and, as regards differentiation, they stand markedly above the more generalised Pachylemuridæ of the European and North American Tertiaries.

Taken all in all, the Santa Cruz fauna has distinctly reached a higher rank than the mammalian groups in the Lower and Middle Eocene of the Northern hemisphere. It can, at the furthest, be placed on a parallel with the Upper Eocene or with the Oligocene of Europe.

Oligocene.

The coal-bearing Lower fresh-water Molasse of the North and South Alps (Upper Bavaria, Switzerland, near Vicenza, Cadibona and Zovencedo in Liguria) and of the Waadtländer highlands (Rochette, near Lausanne); the contemporaneous deposits in Hungary (Gran) and Dalmatia (Monte Promina); the marine sands and brackish marls of the Mayence basin; of the Upper Rhine valley (Lobsann); of the neighbourhood of Paris (Fontainebleau, Etampes); the fresh-water marl of Ronzon near Le Puy, Villebramar, St. Henri, Manosque, and other places in the South of France, and the lacustrine deposits of Hempstead and Colwell Bay in the Isle of Wight, contain a scanty mammalian fauna composed of the following genera:—

Marsupialia.
Didelphys.
Amphiperatherium.

Perissodactyla.
Aceratherium.
? *Ronzotherium.*

Artiodactyla.
Anthracotherium.
Ancodus.
Elotherium.
Plesiomeryx.
Gelocus.

Rodentia.
Theridomys.
Cricetodon.
? *Decticus.*
? *Elomys.*

Insectivora.	Carnivora.	Sirenia.
Tetracus.	*Cynodon.*	*Halitherium.*
	Amphicynodon.	
Creodontia.	**Plesictis.**	Cetacea.
Hyænodon.	? *Elocyon.*	? *Squalodon.*
		? *Balænoptera.*

The Oligocene mammalian fauna only maintains any claim to independence through the abundant occurrence of *Anthracotherium*, *Ancodus* and *Elotherium*. It shares nearly all its genera with the Upper Eocene, of which it shows itself an impoverished descendant. The absence of a considerable number of genera flourishing in the Upper Eocene is worthy of note (*Anoplotherium*, *Diplobune*, *Xiphodon*, *Palæotherium*, *Paloplotherium*, *Anchilophus*, *Pterodon*, *Proviverra*, etc.).

Miocene.

I. The fresh-water deposits, referred to the Lower Miocene, of Limagne (St. Gérand-le-Puy, Cournon, Gannat, etc.), of the Paris basin (Calcaire de Beauce), of the neighbourhood of Mayence (Weisenau, Hochheim, Mombach), Ulm (Haslach, Eckingen, Michelsberg, Eselsberg) contain a tolerably rich and characteristic mammalian fauna which, unfortunately, has only been discovered in a few European localities. It consists of the following genera:[1]—

Marsupialia.	Rodentia.	Cheiroptera.
†**Didelphys.**	†**Theridomys.**	†**Palæonycteris.**
(*Oxygomphius.*)	*†**Archæomys.**	? *Vespertilio.*
†*Amphiperatherium.*	*†**Issiodoromys.**	
	**Myoxus.*	Creodontia.
Perissodactyla.	**Cricetodon.**	†**Hyænodon.**
***Tapirus.**	**Spermophilus.*	
Aceratherium.	*Sciurus.*	Carnivora vera.
***Rhinoceros.**	***Steneofiber.**	(Fissipedia.)
(**Diceratherium.**)	*†**Titanomys.**	†**Cephalogale.**
? *Macrotherium.*		***Amphicyon.**
	Insectivora.	**Stenogale.**
Artiodactyla.	* *Talpa.*	†**Plesictis.**
†**Anthracotherium.**	*† *Geotrypus.*	**Palæogale.**
†**Palæochœrus.**	*† *Echinogale.*	***Potamotherium.**
*†**Amphitragulus.**	***Myogale.**	†**Amphictis.**
†**Dremotherium.**	*† *Plesiosorex.*	**Viverra.**
†**Cœnotherium.**	*Sorex.*	***Herpestes.**
†**Plesiomeryx.**	***Dimylus.**	***Proælurus.**
	*† *Cordylodon.*	
	*† *Palæoerinaceus.*	
	* *Erinaceus.*	

At the first glance this fauna can be recognized as a descendant also of the Upper Eocene and Oligocene faunas. The same orders, and frequently also the same genera, are repeated in all three, and the percentage division of the particular orders shows also considerable uniformity. In the absence of Lemurs, in the marked decline and final extinction of the Marsupials, Creodontia and Anoplotheridæ, in the much greater abundance of particular genera which were of only sporadic occurrence at an earlier period, such as *Anthracotherium*,

[1] The genera marked with * appear for the first time; those with † become extinct, and those marked *† appear in the Lower Miocene and likewise die out in the same.

Palæochœrus and *Dremotherium*, and in the springing up of a considerable number of new genera, as *Tapirus*, *Diceratherium*, *Amphitragulus*, *Steneofiber*, *Titanomys*, *Erinaceus*, *Dimylus*, *Amphicyon*, *Potamotherium*, *Herpestes*, *Proælurus*, and others, depend the differences between the Upper Eocene, the Oligocene and the Lower Miocene faunas of Europe. Amongst the new genera there is, further, no single form for which a corresponding related form could not be found in the Eocene; only in the modification, differentiation and improvement of the older types is the new fauna distinguished from the earlier one. With the exception of some Marsupials, Rodents, Insectivora and Bats (*Didelphys*, *Myoxus*, *Cricetodon*, *Spermophilus*, *Sciurus*, *Talpa*, *Myogale*, *Sorex*, *Erinaceus*, *Vespertilio*), all the larger genera are extinct.

The rich mammalian fauna of the so-called White-River beds, which in North Nebraska, Dakota, Colorado, Wyoming and South Canada cover a very extended area, and reach a thickness of from 40—60 mètres, holds an altogether similar relationship to the Bridger and Uinta fauna, as the fauna of the Lower Miocene of Europe to that of the Upper Eocene and Oligocene. The powerful Amblypoda and the peculiar Tillodontia are extinct, the Creodontia are shrunk up to a single genus (*Hyænodon*); the Prosimiæ are, however, still represented by two genera. For the rest, the White-River fauna consists of Marsupials, Perissodactyla, Artiodactyla, Rodents, Insectivora, Bats, and genuine Carnivora, and the following genera are present in it:[1]—

MARSUPIALIA.
Didelphys.

PERISSODACTYLA.
*†**Mesohippus.**
*†*Tapiravus.*
*Aceratherium (E.)
*†**Hyracodon.**
*†*Metamynodon.*
*†**Titanotherium.**
Diconodon.
Brontops.
Brontotherium.
Menops.
Symborodon.
Megacerops
Titanops.
Allops.
Dalodon.
Teleodus.

ARTIODACTYLA.
*†?*Ancodus* (E.)
*†**Elotherium** (E.)
*†*Perchœrus.*
*†*Leptochœrus.*
*Agriochœrus.
*†**Oreodon.**
*†**Poëbrotherium.**
*†*Gomphotherium.*
*†**Leptomeryx.**
*†*Hypisodus.*
*†*Hypertragulus.*
*†*Protoceras.*

RODENTIA.
*†**Ischiromys.**
*Steneofiber (E.)
*†*Heliscomys.*
*†**Gymnoptychus.**
*†**Eumys.**
*†**Palæolagus.**

INSECTIVORA.
†*Ictops.*
*†*Leptictis.*
*†*Mesodectes.*
*†*Geolabis.*

CHIROPTERA.
*†*Domnina.*

CREODONTIA.
*Hyænodon (E.)

CARNIVORA VERA.
(Fissipedia.)
*†**Daphænos.**
*Galecynus.
*Hoplophoneus.
*†**Dinictis.**

PRIMATES.
*†*Laopithecus.*
*†*Menotherium.*

Amongst the Perissodactyla, *Mesohippus* represents only a somewhat more advanced stage of differentiation of *Epihippus*, and exactly in the same manner *Tapiravus* is related to *Helaletes*, *Hyracodon* to *Hyrachyus*, *Metamynodon* to *Amynodon*. The Titanotheridæ, with an

[1] The genera to which the letter (E.) is affixed occur also in the Miocene of Europe. For the other marks see the note on p. 460.

abundance of species, form, by their gigantic dimensions and their great numbers, a highly characteristic element of the White-River fauna, and they are plainly descended from the Eocene Palæopsinæ. Amongst the Artiodactyla, the Oreodontidæ (*Agriochœrus, Oreodon*), as regards their abundance, take the first place; they are also already represented in the Uinta beds by *Protoreodon*; in a like manner *Poëbrotherium* and *Gomphotherium* show that they are progressive connecting links between the existing Camels and the Eocene Leptotragulidæ. The micro-fauna of the White-River beds is also closely connected with that of the Eocene; on the other hand, the genuine Carnivora, the Tragulidæ (*Leptomeryx, Hypisodus, Hypertragulus*), the remarkable cervine genus *Protoceras*, as also some genera which have probably migrated from Europe (*Aceratherium, Ancodus, Elotherium, Steneofiber, Hyænodon*), stand forth as new forms. It is evident that there was still intercourse between Europe and North America, but whilst in the Older Eocene the new world made a present of its superfluity to Europe, in the Miocene period North America received a greater number of immigrants from Europe.

II. In the Newer Miocene period the area of distribution of the terrestrial mammals in Europe became notably extended. The district between the Alps and the Jura-plateau, heretofore covered by the sea, was now laid dry, or sprinkled over with fresh-water lakes and bogs; in the Vienna basin also the sea is receding, in the Alps (Steiermark) and on the Jura-plateau (Steinheim, Nördlingen, Georgensgmünd) the depressions are filled up with fresh-water and contain the washed-in remains of land animals. A number of localities in the Rhone valley (Grive-St.-Alban), in Switzerland (Winterthur, Käpfnach, Elgg, Chaux-de-Fonds, Vermes), in Upper-Baden (Œningen, Engelswies, Heudorf), on the Swabian-Bavarian high-plateau (Kirchberg, Günzburg, Dinkelscherben, Haeder, Dachau, Munich, Freising, Lower Bavaria), on the Jura-plateau, in the Vienna basin, Steiermark, Hungaria, Roumania, and Bessarabia contain the remains of land mammals, which also are again found to the west of the Central-plateau of France, in the former Aquitanian basin, now deserted by the sea (Sansan, Simorre, St. Gaudens), in Touraine and in the Orléanais, and they have also been discovered in Spain (San Isidro) and Algeria. Italy (Monte Bamboli) has at least yielded traces of the same. The Newer or Middle Miocene fauna consists of the following genera:[1]—

PERISSODACTYLA.
*†**Anchitherium.**
Tapirus.
Aceratherium.
Rhinoceros.
(*Dihoplus.*)
†**Macrotherium.**

ARTIODACTYLA.
*†**Hyotherium.**
**Chœrotherium.*
*†**Listriodon.**
*Hyæmoschus.
(*Dorcatherium.*)
*†**Palæomeryx.**
**Procervulus.*
*†*Micromeryx.*
*†**Dicroceras.**
*†*Protragoceras.*

PROBOSCIDIA.
*Mastodon.
*Dinotherium.

RODENTIA.
Sciurus.
Steneofiber.
Cricetodon.
Myoxus.
**Hystrix.*
*Myolagus.
*Lagomys.

INSECTIVORA.
Talpa.
*†**Galerix.**

[1] See note on p. 460.

*†*Lanthanotherium.*
Myogale.
Erinaceus.
Sorex.
Crocidura.
†*Dimylus.*

CHIROPTERA.
Vespertilio.
Vesperugo.

CARNIVORA.
(Fissipedia.)
*†*Galecynus.*
†**Amphicyon.**
*†*Pseudocyon.*
*†*Hemicyon.*
*†**Dinocyon.**
***Hyænarctos.**
*†*Haplogale.*
†*Stenogale.*
*†*Pseudictis.*
†*Palæogale.*
*†*Proputorius*
**Mustela.*

*†**Trochictis.**
*†*Trochotherium.*
**Enhydriodon.*
Viverra
Herpestes.
*†*Progenetta.*
†*Pseudælurus.*
***Machairodus.**

PRIMATES.
*†**Dryopithecus.**
*†**Pliopithecus.**
*†**Oreopithecus.**

The sudden appearance of Proboscidians (*Mastodon, Dinotherium*) and of genuine Apes (*Dryopithecus, Pliopithecus, Oreopithecus*), the abundance of *Rhinoceros* and *Anchitherium*, the first occurrence of horned Ruminants (*Dicroceras, Procervulus*) and Antelopes (*Protragoceras*), the great development of carnivorous animals which, in their organization, are intermediate between dogs and bears, give to the fauna of the Middle Miocene a stamp fairly distinct from that immediately preceding it, and this is more intensified by the absence of small Cænotheria and Creodontia. The gap between the Middle Miocene and the Lower Miocene fauna is certainly a much larger one than that between this latter and the Upper Eocene fauna. No single species from the Lower Miocene has been preserved unchanged, and even the genera which have continued on from the earlier epoch belong, with the exception of *Aceratherium, Rhinoceros, Viverra, Herpestes*, and *Steneofiber*, to the Insectivora, Rodents, Bats and small Carnivora, which are well known to be only slightly subject to modification. Also the genera of that period, which are still in existence, are, with the exception of *Tapirus, Rhinoceros, Viverra*, and *Herpestes*, representatives of the micro-fauna, and they mostly have at the present time a cosmopolitan distribution. Of the four genera of the larger forms, *Tapirus* lives in India and South America, the three others in the Mediterranean region, Africa and South Asia, thus altogether in strikingly extensive areas of distribution.

The remarkable difference in the mammalian faunas of the Lower and Middle Miocene receives an explanation when it is considered that between them there are interposed, almost everywhere in Europe, thick marine deposits, which must, under any conditions, represent a long period of time, and these only contain remains of marine animals, and yield no information respecting the occupiers of the land in the same interval. The Miocene Thalassotheriæ all belong to extinct genera of Cetacea, Sirenia and Pinnipedia, concerning whose origin complete darkness prevails, as is likewise the case with their scanty forerunners in the Eocene (*Zeuglodon, Prorostomus, Halitherium*). That the shores of Europe and North America were inhabited by similar marine mammals in the Tertiary period follows, moreover, from the wide distribution of certain genera (*Zeuglodon, Squalodon*), and from the general agreement in character

of the fossil Cetacea in the Miocene of Europe and in that of the United States (New Jersey, Maryland, Virginia, Georgia, Carolina). These contain the following genera:—

Europe.		North America.
Cetacea.	Sirenia.	Cetacea.
Squalodon.	**Halitherium.**	? *Delphinodon.*
Champsodelphis.	*Rhytiodus.*	? *Phocogeneus.*
Trachyacanthus.	**Metaxytherium.**	**Squalodon.**
Delphinopsis.	*Miosiren.*	*Zarhachis.*
Heterodelphis.	*Prohalicore.*	*Ixacanthus.*
Priscodelphinus.		*Cetophis.*
Schizodelphis.	Carnivora.	*Lophocetus.*
Macrochirifer.	(Pinnipedia.)	**Priscodelphinus.**
? *Cetorhynchus.*	*Pristiphoca.*	*Rhabdosteus.*
Beluga.	*Monatherium.*	*Agabelus.*
Physodon.	*Prophoca.*	**Balænoptera.**
Hoplocetus.	*Mesotaria.*	
Plesiocetus.		Sirenia.
Cetotherium.		? *Hemicaulodon.*

For the Middle Miocene land mammalian fauna also there is not wanting a parallel in North America. Hitherto only the extreme West, in the territories of Oregon, Nevada and Washington, has yielded those remains, in part so wonderfully preserved, which compose the John-Day fauna. The abundant occurrence of *Rhinoceros*, *Aceratherium*, *Anchitherium*, *Steneofiber*, *Sciurus*, *Lepus* and *Galecynus* shows that European genera could, at that time, still wander to the Pacific Ocean, and even although certain specifically American families, like the Oreodontidæ and the Camelidæ, have experienced a further evolution and increase in number, there are, nevertheless, not wanting representative forms from which a common origin and the former connection of both continents may be inferred. To the oldest horn-bearing mammal in Europe (*Dicroceras*) corresponds in North America *Blastomeryx*, to the remarkable Macrotheriæ and Chalicotheriæ of the old world, the American genus *Moropus*, and also between the Rodents and Carnivora of both continents there are many related links, although the lists mostly contain other names, which, however, mainly indicate similar forms. The fauna of the John-Day beds contains the genera mentioned below:[1]—

Perissodactyla.	*Agriochœrus.*	Carnivora.
Anchitherium (E.)	**Merycochœrus.**	(Fissipedia.)
Aceratherium (E.)	**Blastomeryx.**	**Temnocyon.**
Rhinoceros.		**Galecynus** (E.)
(Diceratherium) (E.)	Rodentia.	*Hyænocyon.*
Moropus.	**Allomys.**	**Oligobunis.**
	Sciurus (E.)	*Enhydrocyon.*
Artiodactyla.	**Steneofiber** (E.)	**Nimravus.**
Boöchœrus.	*Pleurolicus.*	**Pogonodon.**
Chænohyus.	*Entoptychus.*	**Archælurus.**
Bothrolabis.	**Hesperomys.**	**Hoplophoneus.**
? *Thinohyus.*	*Paciculus.*	
Coloreodon.	**Palæolagus.**	
	Lepus (E.)	

[1] The genera to which the letter (E.) is affixed occur also in Europe.

The outlines of the Newer Miocene fauna of North America have been extended by the discoveries in the so-called Deep-River or *Ticholeptus* beds, which are at present known only in Western Nebraska, in the valley of Deep-River in Montana, and in Cotton-Wood Creek, Oregon. The fauna of these deposits is of a somewhat newer stamp than that of the John-Day beds. It is especially distinguished by the occurrence of *Mastodon*. by the great development of the Oreodontidæ (*Merycochœrus, Merychyus, Leptauchenia, Cyclopidius, Pithecistus*) and Camelidæ (*Protolabis*) and by the continuance of *Anchitherium* and *Blastomeryx*. Altogether about 20 species are known from this horizon.

III. In Europe, also, at the close of the Miocene, a fairly radical change in the character of the land mammals takes place. The localities which disclose to us the Uppermost Miocene fauna are relatively few, and mostly widely apart from each other, but some of them are distinguished by the astonishing abundance and the excellent preservation of the remains which are found in them. Thus, for example, at Pikermi, near Athens, from an area of 300 m. in length and 60 m. in width, no fewer than 40 species of mammals have been dug up, and some of these are represented by hundreds of individuals, whilst some of the skeletons are entire. A similar necropolis of ancient mammals has been discovered in Samos, and another at Mount Léberon in Provence. Various localities in the Rhone valley, at the foot of the Pyrenees, in Spain, Algeria, and in Asia-Minor, show that the Pikermi fauna was widely distributed in the Mediterranean region. It is not altogether absent in the countries north of the Alps, but it is there somewhat poorer, it lacks, in particular, certain forms of Ruminants (Antilopidæ, Giraffidæ) which in the south were evidently surrounded by rich grass-bearing Steppes, and these are replaced by forest-loving Deer. The renowned sand-deposits of Eppelsheim near Worms, the Belvedere gravels near Vienna, and the widely-distributed Congeria beds of the Pontis division, in the Vienna basin, Hungaria and Roumania, contain the remains of the Uppermost Miocene fauna which by many authors is referred to the Pliocene. It is composed of the following genera:— [1]

EDENTATA.
**Orycteropus.*

PERISSODACTYLA.
*†**Hipparion.**
Tapirus.
Aceratherium.
Rhinoceros.
(*Dihoplus.*)
*†*Leptodon.*
? *Titanotherium.*
*†**Chalicotherium.**

ARTIODACTYLA.
***Sus.**
Hyæmoschus.
(*Dorcatherium.*)
Cervulus.
*†**Palæotragus.**
*†**Samotherium.**
*†**Helladotherium.**
***Camelopardalis.**
*†**Tragoceras.**
*†**Palæoryx.**
*†**Tragelaphus.**
*†**Palæoreas.**
*†*Antidorcas.*
***Gazella.**
Antilope.

PROBOSCIDIA.
Mastodon.
†**Dinotherium.**

RODENTIA.
†**Steneofiber.**
*†*Acomys.*
Hystrix.

INSECTIVORA.
Sorex.

CARNIVORA.
(Fissipedia.)
*†**Simocyon.**

[1] See note on p. 460.

CARNIVORA, *cont.*	*†*Promephitis.*	***Felis.**
†Amphicyon.	***†Ictitherium.**	**Machairodus.**
†Hyænarctos.	**†Lycyæna.*	
Mustela.	**†Hyænictis.*	PRIMATES.
**†Promeles.*	***Hyæna.**	**†Mesopithecus.*

The strangest constituent of this fauna is the Edentate genus *Orycteropus*, an African type which has maintained itself in the Southern hemisphere of the old world up to to-day. Also amongst the Ruminants, the Giraffes, Gazelles, and numerous Antelopes point to African connections, and they confirm the view that at that time there was a land junction between the Mediterranean region and the dark continent, over which herds of Ruminants traversed. Amongst these far-advanced, almost modern, types, *Helladotherium* and *Samotherium* stand out as relicts of an older period, and also *Mastodon, Dinotherium, Tapirus, Aceratherium, Rhinoceros, Chalicotherium* (which only differs slightly from *Macrotherium*), *Hyæmoschus, Cervulus, Steneofiber, Hystrix, Mustela* and *Sorex* support the continuity with the preceding Miocene fauna. Troops of a slim zebra-like horse (Hipparion) and genuine wild pigs of notable size inhabited at that time almost all Europe, and the abundance of wild game had a corresponding influence on the development of the Carnivora. Hyænas, Cats with powerful teeth (*Machairodus*), Civet-cats (*Ictitherium*), and the forerunners of Bears (*Simocyon, Amphicyon, Hyænarctos*) have yielded abundant remains, and they exceed in number the smaller genera (*Mustela, Promeles, Promephitis*) which have partly been taken over from the Middle Miocene. If there yet remained any hesitation as to the tropical character of this fauna, the occurrence in it of an Ape nearly related to the living *Semnopithecus*, of which dozens of skulls and entire skeletons have been dug up at Pikermi, would remove all doubt. Although the number of still existing races is not much greater than in the Middle Miocene, yet the Upper Miocene fauna wears a distinctly more modern dress, and in several groups it has already almost reached the standard of the existing fauna.

For the determination of the former distribution of the mammalia the discoveries made in different parts of Asia possess a high interest. From the renowned localities in the Sivalik Hills, at the southern foot of the Himalayas, between the Ganges and the Sutlej, Falconer and Cautley had already by the middle of this century reaped a rich harvest; traces of this fauna were shown by the brothers Schlagintweit to be present in Thibet; and also the valleys of the Indus and the Narbudda, and the Island of Perim, in the Gulf of Cambay, further Ava in the Irrawaddy basin, Burma, Java, Sumatra, the Philippines, China and Japan have yielded some sparse remains which speak in favour of an extraordinarily wide distribution of the Sivalik fauna in Southern and Eastern Asia. Through the discoveries in Persia (Maragha) and Asia-Minor (Lake Urmia, Troy), this fauna is brought in direct connection with Europe.

The so-called Sivalik fauna is not of a single independent character, for it clearly contains forms which correspond to those in the European Middle and Upper Miocene and the Older Pliocene. A distinct

division into geological horizons cannot, unfortunately, at present be carried out. Nevertheless, Lydekker considers that certain localities in Sind, Cutch, on the Island of Perim, and in the Sivalik Hills specially contain older types, and others Pliocene forms. The entire fauna consists of about 150 species, which are divided amongst the following genera:—[1]

PERISSODACTYLA.
Hipparion (E.)
? *Hippodactylus.*
Equus (E.*)
? *Tapirus* (E.)
Aceratherium (E.)
Rhinoceros (E.)
(*Atelodus.*)
(*Ceratorhinus.*)
Chalicotherium (E.)

ARTIODACTYLA.
Anthracotherium (E.)
Merycopotamus.
Chœromeryx.
Hemimeryx.
Listriodon (E.)
Hippohyus.
Sus (E.)
Sanitherium.
Hyotherium (E.)
Tetraconodon.
Hippopotamus (E.)
Camelus.
Dorcatherium (E.)
Tragulus.
? *Moschus.*
Palæomeryx (E.)
Cervus (E.)
Camelopardalis (E.)
Helladotherium (E.)
Vishnutherium.
Sivatherium.
Hydaspitherium.
Bramatherium.
Alcelaphus.
Tetraceras.
? *Cobus.*
Gazella (E.)
Hippotragus.
Boselaphus.
Oreas.
Strepsiceras.
Capra.
Bucapra.
? *Ovis.*
Leptobos (E.*)
Bubalus (E.*)
Bison (E.*)
Bos (E.*)

PROBOSCIDIA.
Mastodon (E.)
Dinotherium (E.)
Elephas (E.*)

RODENTIA.
Nesokia.
Rhizomys.
Hystrix (E.)
Lepus (E.)

CARNIVORA.
(Fissipedia.)
Amphicyon (E.)
Canis (E.*)
Hyænarctos (E.)
Ursus (E.*)
Mustela (E.)
Mellivora.
Mellivorodon.
Lutra (E.)
Enhydriodon (E.)
Viverra (E.)
Lepthyæna.
Hyæna (E.)
Æluropsis.
Ælurogale.
Felis (E.)
Machairodus (E.)

PRIMATES.
Cynocephalus.
Macacus (E.*)
Semnopithecus (E.*)
Troglodytes.
Simia.

The agreement of the Sivalik fauna with that of Pikermi, Samos, Léberon, etc., in Europe, is not confined to a very considerable number of common genera but is extended even to the identity of several species. Even if a few remarkable types like *Sivatherium*, *Vishnutherium* and *Bramatherium*, are, up to the present, unknown in Europe, yet the total character of the Upper Miocene mammalian fauna in Europe, North Africa, Asia-Minor, South and East Asia is, nevertheless, so uniform, that this widely-extended region, as regards the geographical distribution of its animals, forms but one natural kingdom, to which North America may be joined as a distinct province with its own differentiated types. That the Camelidæ, otherwise indigenous to North America, also spring to the surface in the East Indies, whilst they are absent in Europe, is a remarkable fact, for, as regards the rest, Europe and North America show closer connections with each other than North America and East Asia. For a number of genera such as *Elephas*, *Bison*, *Bos*, *Bubalus*, *Leptobos*, *Equus*, *Hippopotamus*, *Canis*, *Ursus*, *Semnopithecus*, and *Macacus*, which in Europe first make their

[1] The genera marked with (E) also occur in the European Miocene; those with (E*) in the European Pliocene.

appearance in the Pliocene, Southern India may be considered the original home, even though the Sivalik beds may not contain places, as Lydekker supposes, genuine Pliocene forms.

In strong contrast to the Miocene mammalian fauna spread ov the entire Northern hemisphere, stand the probably contemporaneo forms of the so-called "Patagonia formation," in Patagonia a Uruguay. If one compares the following list of the genera know up to the present from these beds (from which the marine mammal on account of their peculiar conditions of distribution, should excluded) with those from North America, Asia, or Europe, it w be seen that their indigenous South American, or, according Wallace's terminology, "Neotropical," character stands out not le prominently than in the older fauna of Santa Cruz.

MARSUPIALIA.
? *Notictis.*
Apera.
Cynonasua.

EDENTATA.
Gravigrada.

Promegatherium.
Interodon.
Orthotherium.
Pliomorphus.
Menilaus.
? *Gnathopsis.*
Promylodon.
Pseudolestodon.
Lestodon.
Diodomus.
Sphenotherus.
Ranculcus.
Nephotherium.
Strabosodon.

Glyptodontia.
Hoplophorus.
Palæohoplophorus.
Protoglyptodon.
Neuryurus.
Lomaphorus.
Pseudoeuryurus.

Dasypoda.
Proeuphractus.
Stenotatus.
Chlamydotherium.
? *Eutatus.*

PERISSODACTYLA.
Proterotheridæ.
Proterotherium.
Brachytherium.

Macrauchenidæ.
Scalabrinitherium.
Mesorhinus.
Oxyodontotherium.
Macrauchenia.

TOXODONTIA.
Toxodon.
? *Eutomodus.*
Xotodon.
? *Stenotephanus.*

TYPOTHERIA.
Protypotherium.

RODENTIA.
Discolomys.
Morenia.
Orthomys.
Myopotamus.
Eucardiodon.
Anchimys.
Procardiotherium.
Cardiotherium.
Plexochœrus.
Caviodon.
Lagostomus.
Megamys.
Tetrastylus.
Neoepiblema.
Euphilus.
Briaromys.
Gyriabrus.
Calpostemma.
Strophostephanus.
Paradoxomys.
Haplostropha.

CETACEA.
Pontistes.
Pontivaga.
Pontoplanodes.
Ischyrorhynchus.
Balæna.
Notiocetus.

SIRENIA.
Ribodon.

The Marsupials, Edentates, Toxodonts, Typotheridæ, as also th Perissodactyla and Rodents contained in the Patagonian (Miocene mammalian fauna, are all of specifically South American types, else where unknown. It is a more matured offspring of the Santa Cru fauna, and is only distinguished from it by a stronger differentiatio of particular genera. There is no trace of any intermixture of foreig elements which would indicate a connection with North America o with the fauna of the Northern world.

(*To be concluded in our next Number.*)

ERRATUM.—Page 409, column 1, in last number, for *Artaodactyli* read *Artiodactyl*

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—Nottingham Meeting, September 13–21, 1893.

TITLES OF PAPERS READ BEFORE SECTION (C), GEOLOGY.

President:—J. J. H. TEALL, M.A., F.R.S., Sec. Geol. Soc.

The President's Address.

Prof. E. Hull.—Note on the Water-bearing Capacity of the New Red Sandstone of Nottinghamshire.

Prof. F. Clowes.—On a Nottingham Sandstone containing Barium Sulphate as a Cementing Material.

C. E. De Rance.—Report of the Committee on the Circulation of Underground Water.

Prof. E. Hull.—On the Discovery of a Concealed Ridge of pre-Carboniferous Rocks under the Trias of Netherseal, Lincolnshire.

J. L. Myres.—Geology of the Coast Land of Caria.

Prof. T. Rupert Jones.—Report of the Committee on the Fossil Phyllopoda of the Palæozoic Rocks.

Dr. R. H. Traquair.—On the Discovery of *Cephalaspis* in the Caithness Flags.

M. Laurie.—Report on the Eurypterid-bearing Deposits of the Pentland Hills.

Montagu Browne.—On some Vertebrate Remains not hitherto recorded from the Rhætic Beds of Britain.

George Fowler.—Note on a Fault at Cinder Hill.

Dr. H. Hicks.—On the Base of the Cambrian in Wales.

E. T. Newton.—On the Reptilia of the British Trias.

Discussion on the Limits of Geology and Geography.

Prof. J. P. Iddings.—The Dissected Volcano of Crandall Basin, Wyoming. Illustrated by Lantern Slides.

Sir A. Geikie.—On Structures in Eruptive Bosses which resemble those of Ancient Gneisses.

Prof. W. J. Sollas.—On the Pittings in Pebbles from the Trias.

Dr. V. Ball, C.B.—On Bones and Antlers of *Cervus giganteus* incised and marked by mutual attrition, while buried in Bogs or Marl.

Prof. W. H. Herdman.—Note on the exhibition of a mass of cemented shells, dredged from the sea bed.

R. D. Oldham.—Note to accompany the exhibition of a Geological Map of India.

Walcot Gibson.—Geological Sketch of Central East Africa.

Dr. H. J. Johnston-Lavis.—Report of the Committee on the Volcanic Phenomena of Vesuvius.

Dr. H. J. Johnston-Lavis.—Quartz Inclusions in Lava of Stromboli.

A. T. Metcalfe.—On the Gypsum Deposits of Nottinghamshire and Derbyshire.

O. W. Jeffs.—Report of the Committee on Geological Photographs.

H. B. Woodward.—On a Bed of Oolitic Iron Ore in the Lias of Raasay.

A. C. G. Cameron.—Note on a Transported Mass of Chalk in the Boulder Clay of Catworth, Huntingdonshire.

J. G. Goodchild.—Augen-Structure in relation to the Origin of Eruptive Rocks and Gneiss.

Prof. W. C. Brögger.—The Genetic Relations of the Basic Eruptive Rocks of Gran (Christiania region).

A. Harker.—Berthelot's Principle applied to Magmatic Concentration.

Prof. W. J. Sollas.—On the Origin of Intermediate Varieties of Igneous Rocks by Intrusion and Admixture, as observed at Barnavave, Carlingford. Illustrated by Lantern Slides.

Prof. W. J. Sollas.—On the Transformation of an Amphibolite into Quartz-Mica-Diorite. Illustrated by Lantern Slides.

W. W. Watts.—On the Hornblende-Pikrite of Greystones, co. Wicklow.

F. T. Howard and *E. W. Small.*—On some Igneous Rocks of S. Pembrokeshire, with a note on the Isle of Grassholme.

A. Smith Woodward.—Report of the Committee on the Registration of Type Specimens of Fossils.

Discussion on Coral Reefs (Fossil and Recent). Opened by *Prof. W. J. Sollas.*

Prof. C. Lapworth.—The Trias of the Midlands.

Rev. A. Irving.—Twenty Years Work on the Younger Red Rocks.

Baron von Reinach and *W. A. E. Ussher.*—Note on the exhibition of *Schizodus* and *Aucella Hausmanni* from the Magnesian Limestone of Bulwell.

Prof. E. Hull—Note on the Himlack Stone.

J. W. Gray and *P. F. Kendall.*—On the Permo-Triassic Junction at Stockport.

R. B. Newton.—Note on some Molluscan Remains lately discovered in the English Keuper.

H. Bolton.—On the Skiddaw Slates of the Isle of Man.

Prof. J. Milne.—On the Volcanic Phenomena of Japan. Illustrated by Lantern Slides.

Howard Fox.—On the Radiolarian Chert of Cornwall. Illustrated by Lantern Slides.

Discussion on Geological Education. Opened by—
Prof. G. A. J. Cole.—On Geology in Intermediate Education.
Prof. G. A. Lebour.—On Geology in Professional Education.

Prince Kropotkin.—On the Glaciation of Asia.

Prof. T. G. Bonney.—On some Assumptions in Glacial Geology.

C. A. Lindvall.—The Glacial Period, its Origin and Effects.

Dugald Bell.—Report of the Committee on the High-level Shell-bearing Deposits at Clava, Chapelhall, and other localities.

P. F. Kendall.—Report of the Committee on Erratic Blocks.

Prof. W. J. Sollas.—A Map of the Esker Systems of Ireland.

P. W. Abbott and *P. F. Kendall.*—On some Supposed Evidence of the Recent Submergence of North Wales.

Dugald Bell.—On some Shelly Clay and Gravel in the North-East of Aberdeenshire.

C. E. De Rance.—On the Pre-Glacial Form of the Ground in Lancashire and Cheshire.

Dugald Bell.—On the Granite Boulders of the Clyde Valley.

H. Arnold-Bemrose.—The Toadstones of Derbyshire. Illustrated by Lantern Slides.

Prof. W. J. Sollas.—On the Minute Structure of the Skeleton of *Monograptus priodon*. Illustrated by Lantern Slides.

W. W. Watts.—On Perlitic Structure in Quartz. Illustrated by Lantern Slides.

In other Sections—

Prof. Stirling.—Note on the Discovery of *Diprotodon* Remains in Australia.

Report of the Committee on Earth Tremors.

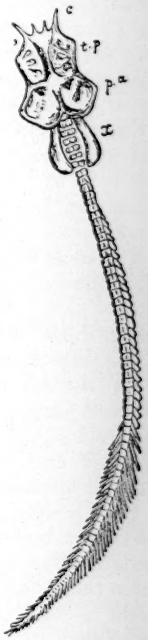
Report of the Committee on the Volcanic and Seismological Phenomena of Japan.

REVIEWS.

I.—A Further Description of *Palæospondylus Gunni*. By Dr. R. H. Traquair, F.R.S., Proc. Roy. Phys. Soc. Edinburgh, vol. xii. 1892–93, pp. 87–94, pl. i.

THIS little organism, it will be remembered, is a supposed fossil Marsipobranch fish, first briefly described three years ago by Dr. Traquair, from the Old Red Sandstone of Achanarras, Caithness. A more detailed account of the genus and species is now given, and the author adds the accompanying restored sketch.

The organism is now shown to be destitute of jaws: and it still remains uncertain whether or not the nose was a paired organ. The supposed dorsal shield behind the head proves to consist of a pair of oblong plates, apparently not external; and between these the ring-vertebræ are spaced, while behind they form a continuous chain. There are short and stout neural spines in the abdominal region, but no ribs. No traces of paired limbs can be detected in any specimen.



Restoration of *Palæospondylus Gunni* (somewhat enlarged), by Dr. R. H. Traquair. *c.* cirri; *t. p.* anterior part of cranium; *p. a.* posterior part of cranium; *x.* paired plate-like structure behind the head.

II.—Contributions to the Tertiary Fauna of Florida. Part II. Streptodont and other Gastropods, concluded. By Dr. William H. Dall. (Trans. Wagner Free Inst. of Science of Philadelphia, Vol. III. Part II.).

THE Caloosahatchie beds, from which many of the mollusca described in this work were obtained, are the only marine Pliocene deposits of the Eastern United States of which the geological age has been admitted without controversy since they were first described. This memoir of Dr. Dall's, therefore, serves a double purpose, first to describe the unique fauna, and secondly to constitute a standard with which other Upper Tertiary beds may be compared.

The Introduction is practically a paper "On the Marine Pliocene Beds of the Carolinas," wherein the correlative value of the Floridian deposits is already manifest. In the course of his studies, the author had, necessarily, to deal with the classic faunas of the Tertiaries of North and South Carolina described by Tuomey, Holmes, Conrad, Lyell, and others. Hitherto the age of these beds has been a subject of much dispute, as to whether they are Miocene or Pliocene; up to within the past few years they have been regarded as transitional, and in 1884 received the appellation "Upper Atlantic Miocene." It has been reserved for Dr. Dall to show that the fauna is not a natural one; in other words the fauna catalogued and illustrated by Tuomey and Holmes in their "Pliocene Fossils of South Carolina" was not a true fauna at all, but a mixture of several distinct faunas, of which one was of true Miocene age, like the Virginian Miocene, whilst another might reasonably be regarded as genuine Pliocene, and the stratigraphical equivalent in South Carolina of the Caloosahatchie beds of Florida. Of course, it was not possible to accurately determine such points as these without appealing to the sections from which the fossils were derived, and this work was undertaken by Mr. Joseph Willcox, of Philadelphia, with the assistance of Mr. C. W. Johnson. The last mentioned observer carefully examined the strata along the Waccamaw river in South Carolina, and subsequently those on the Neuse river in North Carolina; and the name of Waccamaw beds is now proposed for the former, and Croatan beds for the latter, both being included in the Floridian group. The determination of the fossil mollusca obtained has enabled Dr. Dall to show that by throwing all the doubtful species into the category of extinct forms, there are from the Waccamaw beds 125 out of 180 species still found living, or about 70 per cent.; whilst from the Croatan beds there are 80 out of 96 species represented in the recent fauna, or over 83 per cent. Thus, the Pliocene age of the beds is obvious.

From these and other considerations, the author has been led to establish a new classification for the later Tertiaries of Eastern United States, as follows:—

Later Eocene.

Vicksburg group (Jackson, Vicksburg, and Salt Hill formations).
Ocala group (Nummulitic beds of Florida).

MIOCENE.

Chipola Epoch.

Chattahoochee group (Hawthorne and Ocheesee beds).
Tampa group (Shiloh marl, Tampa and Chipola beds).

Chesapeake Epoch.

Chesapeake group (Maryland, Virginia, etc.).
Grand Gulf group (Grand Gulf beds, Altamaha Grit, etc.).

PLIOCENE.

Floridian Epoch.

Lafayette group (Lagrange beds, Orange sand, etc.).
Floridian group (Caloosahatchie, De Sota, Waccamaw beds, etc.).

After this digression on the author's part, which may be excused on account of its exceptional interest, the shells are described, commencing with a few which in reality form a supplement to Part I. of the work. Passing by some of these we arrive at the new genus *Glyptostyla*, of which *G. panamensis*, a new species from the Miocene (?) of the Isthmus of Panama, near Colon, is the type. We do not quite see the reason for the inclusion of a Central American form in a work devoted to the Tertiary Mollusca of Florida; nevertheless it may be said that the species on which the genus is founded is extremely puzzling. "It recalls *Pyrula* by its external characters, *Turbinella* and *Mazzalina* by its solidity and heavy outer lip, *Latirus* and *Volutilithes* by its plaits."

The genus *Ptychosalpinx*, Gill, is revised, and the American species referable to it are enumerated. The author does not agree with Mr. R. B. Newton's suggestion to adopt the name *Triplex* (Humphrey) Perry, for *Pteronotus*, Swains. pre-occupied; on the ground that Humphrey's name was never illustrated or defined by him, whilst Perry's *Triplex*, is in reality a synonym of *Chicoreus*, Montfort, although he admits that possibly one of the ten species Perry illustrates may belong to *Pteronotus*—as it certainly does. The question seems to hinge on the acceptance, or otherwise, of Humphrey's work, which is not usually admitted (except when convenient) by malacologists. (By-the-bye, we notice that Dr. Dall himself has not hesitated to use a name, *Scala*, proposed by Humphrey.) For the American forms the author now uses *Pteropurpura*, Jouss.

The genus *Obeliscus* is regarded as synonymous with *Pyramidella*; and the author gives a good account of the origin (shall we say evolution ?) of the name *Odontostomia*, Jeff., and gives a new scheme for the classification of the species of *Turbonilla*. He remarks, with reference to the latter, that the attempt to transfer all the plaited species to *Odontostomia* has been a failure, and that many of them will have to re-enter this genus when better known.

The reasons for separating *Seila* from *Cerithiopsis* are carefully worked out and a useful description of the soft parts of the animal of the recent *S. Adamsi* is given, which species ranges from the Miocene. *Cinctella* is referred to as a synonym of *Seila*; but *Lovenella*, Sars. (which name does not stand, however, by reason of

pre-occupation), and *Læocochlis*, D. and M., are very properly regarded as distinct from that genus.

Some very suggestive observations are made under *Cerithium* which deserve to be made more widely known. The author remarks and we think pertinently, that the sub-divisions into which the genus has been split up are worthy of more extended comparative study than they have hitherto received, but unfortunately does not attempt to enter much into detail in regard to the matter for reasons that are sufficiently obvious, in a special work of the kind under review. He states, however, that in sorting over large numbers of specimens of one species, either recent or fossil, it will be noticed that there are two sets as it were, otherwise similar, one much more slender than the other. We can quite bear out this observation in regard to many European Tertiary fossils belonging to the group. This, he says, may be a sexual difference; it is observable in *Bittium* and *Seila* also. "The principal variations of the species are; 1st, size, there being in almost any large lot a few or possibly many dwarfs, otherwise similar—recalling the difference of size in *Cypræa*; 2nd, in the intensification of (*a*) the transverse wavy sculpture, which, in any species which has it, may be strong, weak, or wholly absent; (*b*) the nodulations or tessellations of the primary spiral bands or revolving ridges, which vary in the same species from obsolete to very sharp and prominent; (*c*) the prominence of the primary bands, which is very variable, apart from the nodules they may bear. The secondary fine striation, as in *Buccinum*, is much more constant in its features than the coarser sculpture."

The only reservation we would make to this is, that unless in possession of very ample materials the palæontologist would have some difficulty in determining how far the variations recorded might be regarded as of specific value; whilst it is certain that what might be called a mere deviation from the type in some very variable species would in others, usually more stable, be looked upon as characters having a higher importance. It has been remarked that the scarcity of Cerites is characteristic of the American Tertiary, but our author thinks that this is due rather to ignorance of the fauna than to anything else, and he makes substantial additions in the present paper to the number of species of *Cerithium* hitherto known to occur in the United States.

The author has given considerable attention to *Turritella*, which in some respects is a most unsatisfactory genus to deal with. In speaking of *T. subannulata*, Heilp., he refers at some length to the variation which that species exhibits, and states that some people would find fifty or sixty "species" amongst the material in which he can only see one. There is much wholesome criticism in the general tendency of this remark, but at the same time we should be careful to make it apply all round. Given "enough material" it should be possible to trace gradations from most of the "species" of a genus, through space and in time, to one another. We quite sympathize with the author in his difficulties where a mass of

material is available, yet it seems to us to be quite as convenient to give a "specific" name to the extreme types of variation as to further burden the forms by adding a varietal cognomen—no one, in the present state of our knowledge as to the value of a molluscan "species," is likely to be deceived thereby. The case at present stands thus:—If you have, say, four shells which can be readily distinguished from one another and exhibit a certain amount of striking difference, they would be called four "species," without hesitation; if, however, "enough material" be subsequently obtained and forms are found linking these four together, they would be regarded as one species only, but by way of compensation for the degradation thus sustained they would, perhaps, receive varietal names.

We are not going to defend the "nouvelle école" to which Dr. Dall applies some well-merited strictures, on account of its "hair splitting" propensities; but it may be pointed out that if fig. 4 of plate xvi. of the work under review is to be regarded as the same species as that depicted on the same plate, fig. 1, viz. *Turritella subannulata*, then fig. 4 (var. *acropora*, Dall) and the whole of the forms included thereunder ought to be rigorously compared with *T. acutangula*, Brocc. (syn. *T. subangulata*, Brocc.), of the Southern European Miocene and Pliocene. The gaps existing between the American and the European species alluded to are very slight, and could easily be bridged over. We possess specimens of both species, and some of the latter which we have from the Miocene of Pontlevoy (near Tours) are practically identical with the var. *acropora*. It would not be difficult to multiply examples of this kind, but we content ourselves with the foregoing for the present.

This seems a fitting opportunity to remark on the ornate appearance of many of the North American Tertiary *Turritellæ*; we have observed that wherever this genus is very abundant in the fossil state in Europe it is usually more ornate than where it is sparsely represented, especially as far as the Pliocene is concerned. But we have nothing on this side to compare with Heilprin's *T. perattenuata* from the Floridian Pliocene; amongst other things it attains a length of 135·0 mm. with a maximum diameter at base of 13·5 mm. and exhibits no less than 44 whorls! Specimens of *T. apicalis*, Heilp., in our possession have 23 and 24 whorls respectively.

The genus *Solarium* comes in for a good share of attention. Dr. Dall remarks that it occurs abundantly in the American Eocene, but has been generally misunderstood, the small Trochoid pearly shells properly called *Solariella* having in the United States, as in Europe, been frequently described under the name of *Solarium*, which latter is never pearly, and belongs to a wholly diverse line of development. The examination of the fossil species has led our author to subdivide the genus into sections. He remarks that the form of the shell in most of the groups may vary by having—(1) the whorls rounded at the periphery; or (2) the periphery keeled; or (3) with a shallow, wide sulcus on the top or base of the whorl near the periphery; or (4) by having the spiral sculpture

simple or granular along the threads. The following are the sections of *Solarium* proposed: (1) *Solarium, sensu stricto,* Type *S. perspectivum,* Lamk.; (2) *Solariaxis,* Type *S. elaboratum,* Conrad; (3) *Patulaxis,* Type *S. scrobiculatum,* Conrad; and (4) *Stellaxis,* Type *S. alveatum,* Conrad.

Passing to the genus *Calyptræa* we may notice that *C. trochiformis,* Lamk., has to give way to the earlier *C. aperta,* Sol., with which it is synonymous. It is noteworthy that a form so characteristic of the European Eocene as *C. aperta,* should be found not only in the Lower Tertiary of Claiborne and Vicksburg but ranging up into the newer Miocene of the United States. When the Tertiary molluscan faunas of both sides of the North Atlantic have been rigorously compared—especially the Eocene—we have no doubt that many more forms than have hitherto been discovered will be found to be common to each continent.

When we reach *Crepidula,* Lamk., 1799, we find that the author adopts this name instead of *Crypta,* Humphrey, 1797, which is thus anterior, on the ground that the last-mentioned author's name was proposed "in an auction catalogue, without figure, diagnosis, or reference to literature," and we quite agree with this decision; yet in another part of the work we see that the name *Ampullinopsis,* Conrad, 1865, is retained as a section of *Ampullina,* and *Megatylotus,* Fischer, 1885, is cited in the synonymy, in spite of the circumstance that Conrad's name was never defined, whilst that of Fischer is properly established—a fact of which the author appears to be perfectly cognizant. He complains that M. Cossmann has omitted to state the occurrence of *Megatylotus crassatinus,* Lamk., in his monograph on the Paris basin—we may observe that the French author alluded to confined his attention in that work to the fossils from the Eocene—the species will be found duly recorded in its proper place in his later Oligocene monograph.

In regard to *Dentalium,* Dr. Dall remarks that although Stoliczka has divided the group into a number of genera and two sub-families, he suspects that the differences upon which they are chiefly based, such as the supposed forms of the foot in *Siphonodentalium* and *Dentalium* proper, are less important than might be supposed from the few published figures, and require further investigation before they can be safely used in systematic work. He therefore retains the old nomenclature for the present. As it is impossible to discriminate, in dealing with fossil species, between those belonging to *Cadulus* and *Siphonodentalium,* he refers all the forms treated of to the former genus, and cites *Gadus* in the synonymy.

The work is accompanied by an excellent geological map of Florida, by Dr. Dall, which is reproduced, by permission, from Bulletin No. 84 of the United States Geological Survey, in which our author fully discusses what is known of the geology of the State.

The importance of this work to students of the mollusca cannot be overrated. It is true that here and there a few blemishes occur, as was inevitable in a book of such magnitude. The principal fault we have to find is that the author's title is too restrictive

—too modest. A large number of forms found outside Florida are figured and described. In many respects Dr. Dall's work may be regarded as a species of text-book on the Tertiary Mollusca of the United States, having especial reference to Florida. In several instances all the known fossils of a genus occurring in America are alluded to under the description of that genus; and a good deal of critical revision is effected in almost every branch. It is the work of a thorough master of the subject, and we look forward with considerable interest to the appearance of Part III. in which the author hopes to begin and conclude the description of the bivalves, and to give a general summary and tables. G. F. H.

CORRESPONDENCE.

THE PEBBLE-RIDGE AT WESTWARD HO.

Sir,—The Pebble Ridge at Westward Ho has often been noticed by geologists, and was the subject of a paper by Mr. Pengelly, F.R.S., so long ago as 1868.[1] During a recent visit my attention was attracted to a peculiarity in the "pebbles," which, although not referred to by Mr. Pengelly, can scarcely have escaped observation. So far as I am aware, however, the said peculiarity has not been recorded. The feature referred to is the concentric lamination often induced in "pebbles" above a few inches in diameter. An outside coat about $\frac{1}{16}$ of an inch in thickness peels off, and often underneath the first a second layer comes away. Thus the "pebbles" exhibit all the appearance of a concentric concretionary structure. But as the "pebbles" can be traced to their origin in rhomboidal or rectangular blocks of the local grits, the concentric structure, following the varying curves of the rounded "pebbles," must necessarily be induced and not original. Although this structure is very common I could not find a single instance in a "pebble" sufficiently small and light to carry away in my pocket. It is confined entirely to weighty stones. It would almost seem as though we had in these rounded "pebbles" a sort of pseudo-concentric cleavage caused by percussion, and if so we may possibly find in these "pebbles" a clue to the concentric concretionary structure often noticed by geologists, and which in certain cases may be due not so much to crystallization as to pressure acting equably on the surface of a nodule enclosed in softer strata. However, my object in writing is to call attention to a significant fact rather than to attempt to explain it. A. R. Hunt.

Torquay.

THE RELATIVE AGE OF FLINTS.

Sir,—I have to thank Mr. Jukes-Browne for his article on the Relative Age of Flints in your July issue. His paper is a valuable contribution, and will materially assist the workers in this most difficult subject by directing their attention to those points which most require elucidation.

I gather that, as regards tabular flint, he believes it was formed in

[1] Trans. Dev. Assoc. 1868, p. 415.

fissures, and that microscopically it has the same appearance as flint from the Nodular layers. At present I must confess to being ignorant of his reason for putting flint floors in a separate classification. Is it simply their wide extent? True, they are generally quite solid and free from the cavities so common in the more vertical sheets of flint, but this, I had supposed, was due merely to the horizontal position favouring the deposit of silica because of the slower current of water.

These horizontal layers, whatever their origin, show, with this exception, the same signs as the others of having been formed originally of two plates, and probably in open joint-planes. Should Mr. Jukes-Browne's suggestion that the flint was deposited in cracks during the first upheaval of the chalk be correct, we must believe that these cracks often extended at least through 100 ft. of soft chalk saturated with sea-water, and that many of these fissures were far from being vertical, frequently at an angle of only 30° with the horizon.

My suggested explanation of the absence of flint in the Lower Chalk only referred to the beds in our S.E. district, and I take it that Mr. Jukes-Browne's experience does not refute my belief that wherever there are nodules in the Lower Chalk they are also present in the Upper Chalk, but not *vice versa*. He is doubtless aware that it has been asserted that the total percentage of flint in different beds is roughly the same. If this be true, surely we must look to segregation as the cause of all the visible flint in the cretaceous strata, and the question is, when did this process take place?

The varying character of flints in successive zones is doubtless of importance, but does not prove that flint was contemporaneous with the chalk; though evidence of the traces of the *soft* parts of organisms in flint would probably be conclusive, and I should be glad to hear if such have been found.

The cores I spoke of are not tubular, and I still fancy are not formed round Doryderma, though probably confined to one particular zone. The outer coats of these flints are generally shaped like a potato, hollow inside, with a solid cylindrical core passing through from end to end. This is the simplest form, but sometimes other cores cross the first at various angles. I should be glad to submit specimens to Mr. Jukes-Browne if he would care to see them.

These cores, as well as some other flints I have, containing remarkable loose kernels, lead me to ask him to allow me to add "Mechanical Flints" to his classification, and to include concentric circles of flint with his Paramoudra division.

I can only briefly touch on the chemical influences involved, except that I doubt that Mr. Jukes-Browne's theory of the precipitation of silica through contact with carbonated water can be accepted; but his paper was all too short, and I should be glad if in some future communication he would give us his views as to the sources whence the large quantity of silica for Flint-floors, etc., was derived.

GEORGE ABBOTT, M.R.C.S.

TUNBRIDGE WELLS, *Aug.* 1, 1893.

OBITUARY.

DAVID HOMFRAY.

BORN JUNE 21, 1822. DIED JUNE 22, 1893.

Through the death of Mr. David Homfray, of Portmadoc, we have been deprived of one of the pioneers of Geology in North Wales. When but a mere youth Mr. Homfray left his home, Witley Lodge, near Hales Owen, Warwickshire, for Portmadoc, where his uncle, who was Manager of the Welsh Slate (Palmerston's) Quarry at Ffestiniog, resided. He took to the law, and was for many years, up to the time of his death, Clerk to the Justices of the Peace for the Penrhyndendraeth Division.

Prof. Sedgwick says that North Wales, when he entered it in 1831, "was little more than *terra incognita*," and it was not until after 1857 that Mr. Salter determined by their suite of fossils that the Tremadoc Rocks deserved to be ranked as a separate formation. These fossils were, to a very large extent, collected by Mr. Homfray, as, shortly after 1850, we find him, encouraged by Salter, employing his leisure in working the Portmadoc district, where, especially in the Tremadoc rocks, he discovered many new forms, several of which were named by Salter in honour of him, e.g. *Niobe Homfrayi*, *Asaphus Homfrayi*, *Conularia Homfrayi*, etc. As early as 1859 he presented to the Privy Council on Education a series of Trilobites, etc., illustrative of the Geology of the Lingula Flags of Portmadoc.

At Mr. Salter's request he searched for, and worked, the Menevian-beds of the Maentwrog Waterfall Valley, which beds were then only known at St. Davids through the labours of Dr. Hicks, F.R.S., and Mr. Salter. Here Mr. Homfray met with his usual good success, which led Salter to say of him: "He can find anything he likes in his territory." At Maentwrog he discovered for the first time in Britain, *Conocoryphe coronata*, Barr., and *Conocoryphe Homfrayi*, Salt. Having made an exhaustive study of the rocks of his own district, he visited Dr. Hicks' ground at St. Davids in 1872, and with Dr. Hicks and others worked at the Tremadoc rocks of Ramsay Island. He again visited St. Davids in Dr. Hicks' company in 1874. He spent a considerable portion of the summer of 1875 in accompanying Professors Ramsay and Etheridge, and Mr. Ward, in mapping the Garth Grit, and otherwise revising the Geology of North Wales. The numerous references to Mr. Homfray's labours, and quotations of his opinions in Ramsay's "Geology of North Wales," prove what a high opinion the latter entertained of him.

It is seldom that we meet with a geologist who has toiled so hard, and amassed such a store of valuable information, but has never published an article on his favourite subject. Such, however, was the case with Mr. Homfray. He was content with supplying information to others, which he always did most readily. The same generosity characterized him in giving away his specimens, for he not only gave away his duplicates, but often the only specimen he possessed of a rare species.

When he made a present to the Woodwardian Museum in 1869,

Salter writes: "Sedgwick is so pleased, his face quite glowed," an Sedgwick himself writes: "Most sincerely do I thank you for you kind letter, and for so kindly allowing us to select from the spec mens what we think most important to our Museum. At the sam time, I feel a difficulty in accepting (not of course on my own accoun but on that of the University) some of your specimens, whic are of inestimable value; the grand, almost perfect specimen, *Paradoxides* is (so far as I know) unrivalled and above comparison. In October, 1872, after another consignment, Sedgwick writes "In the number and value of the fossils you sent us you stan foremost in our list." Many of Mr. Homfray's fine specimens ma also be seen in the British Museum (Natural History), and in th Owen's College Museum, Manchester.

Though he could in later years hardly keep pace with the advanc of Geological Science, he took the keenest interest in it up to th time of his death, and gave, as the writer can testify from experience every encouragement to younger lovers of his favourite science. I addition to being a Geologist, he was also an enthusiastic Botanist and a devoted student of Natural History in general.

Dr. Hicks, who kindly read over these notes, says: "I can endors every word you say in regard to the generous and estimable frien whose death we all lament. His keen eye, combined with shrew observation and a highly sympathetic nature, has rendered invalu able service to Cambrian geology, and can only be realized by thos whose pleasure it was to be with him in the field. When Salte and I were working on the Menevian rocks, now nearly thirty years ago, dear David Homfray was the first to offer assistance, and to b ready to join us in our explorations. I can never forget what we owe to his enthusiasm and to his delightful companionship. He was in truth a typical scientific man, who loved truth for truth's sake only, and cared little for the honour which it brought."

Mr. Homfray bore a painful illness with great courage; and by those who knew nothing of his geological labours he will long be remembered, as he was described in a local magazine, "a strict, upright, generous, charitable, and hospitable Christian gentleman."

G. J. Williams.

GEORGE WILLIAM SHRUBSOLE, F.G.S.

This well-known local geologist was born about 1827–28, and belonged to the Kentish family of the same name. He settled in Chester some forty years ago as assistant to a chemist, and in the course of a few years opened an establishment of his own in Market Square, which is still in the hands of his sons. Mr. Shrubsole was the Honorary Curator of the Grosvenor Museum, was an enthusiastic geologist, botanist, and antiquary, and was one of the founders, with Charles Kingsley, of the Chester Society of Natural Science. Mr. Shrubsole's health began to break in 1891, and although he submitted to an operation and was restored for a time, complications arose six weeks before his death, which occurred on the 22nd July, 1893.